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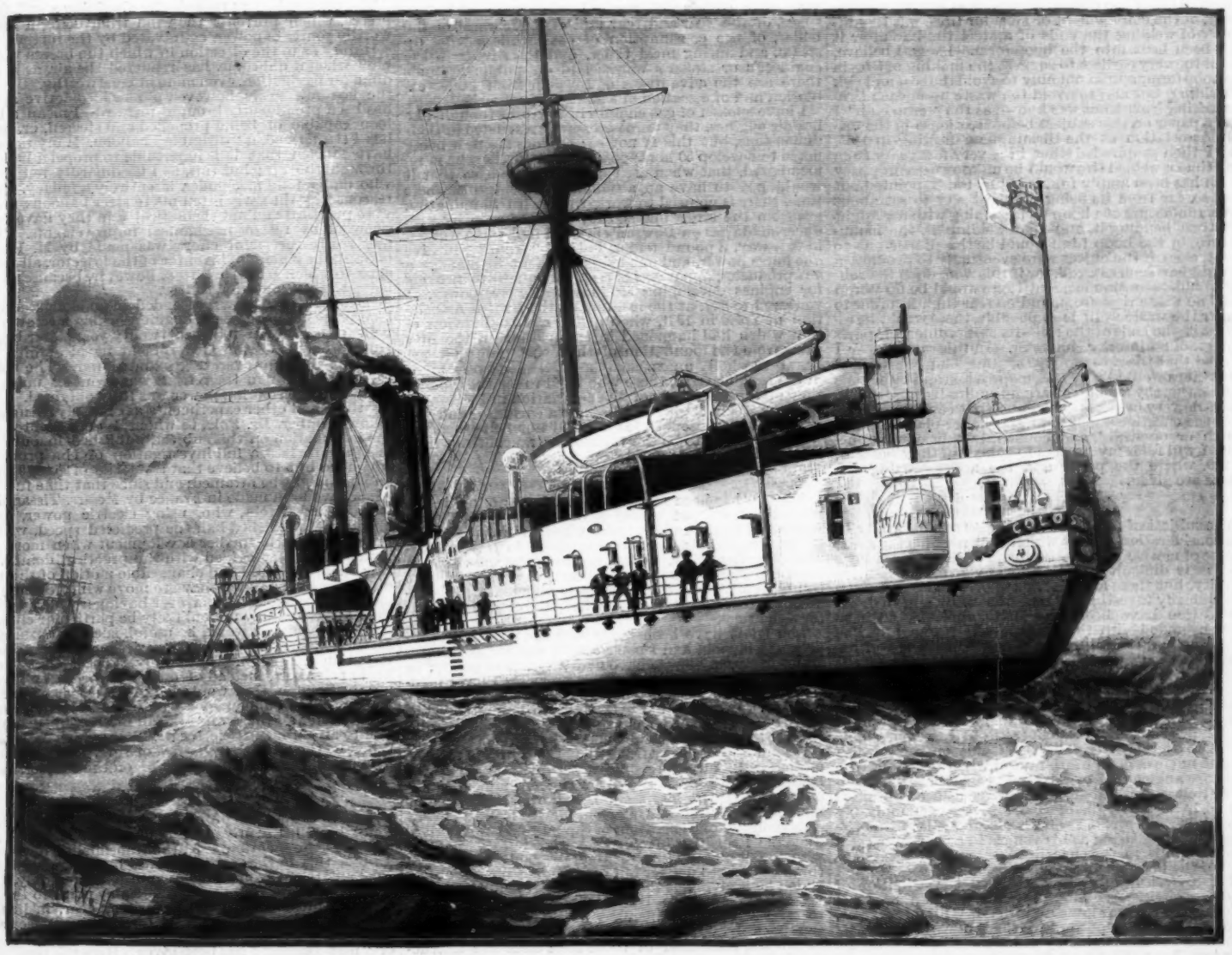
H.M.S. COLOSSUS.

EVERY serviceable addition of new ships to our navy, in spite of the perplexing controversies of scientific and nautical experts about the floating and fighting capabilities of some recently constructed, must be hailed with satisfaction by the anxious British public. We present an illustration of the Colossus, a steel ship, armor-plated with 18 inches thickness of armor, carrying four 42-ton guns in two turrets and four 6-inch guns, resembling the Inflexible in her general arrangement. The Colossus is the first steel ship built in Portsmouth Dockyard, where her keel was laid down in June, 1879; she is now in the reserve division at Portland. The dimensions of this ship are: length between perpendiculars, 325 ft.; extreme breadth, 68 ft.; draught of water, 25 ft. 9 in.; displacement, 9,150 tons. Her engines are of 6,000 indicated horse power, and she carries 950 tons of coal. The complement of officers and men is 345. The Majestic, built at Pembroke, is a sister ship to the Colossus.—*Illustrated London News.*



THE NEW BRITISH WAR SHIP COLOSSUS, TWIN-SCREW, DOUBLE-TURRET IRONCLAD, 9,150 TONS, 6,000 HORSE POWER, EIGHT GUNS.

[Continued from SUPPLEMENT, No. 488, page 7787.]

ENGINEERING INVENTIONS SINCE 1862.*

By Sir F. J. BRAMWELL.

IRON AND STEEL.

LEAVING the old-world materials of stone and wood, let us come not only to the bronze age, but to the iron age, and direct our attention during a few minutes to the improvements which, in twenty-two years, have been made, and first to deal with that form of iron known as steel. I am aware that I am laying myself open to a charge of having committed a most tremendous "bull," but I am prepared to defend my form of speech, on the very strong ground that no one can say, speaking as a metallurgical chemist, where the dividing line is between commercial iron and commercial steel, for it is quite certain there is material which would be currently bought and sold and used as steel which is more near to pure iron than is other material which would be commercially bought and sold and used as iron. It is now nearly eight years since I delivered, at the Royal Institution, a lecture on "The Future of Steel," and every year that has passed has justified the opinions I then ventured to put forward as to the way in which steel made by fusion would supersede iron made by the puddling process; and I am not afraid to repeat my prophecy that the time will come when the use of iron made by that process will be restricted to the manufacture of the small articles produced by the hand labor of the village blacksmith, for whose art its plastic character and ready power of welding eminently fit it. Probably the first great revelation in steel manufacture was the exhibition of the ingots, with other products, shown by Krupp in the 1851 exhibition; it soon became known, however, that these exhibits after all gave us no further information than this, viz., that it did not follow because the limit of the charge of a crucible might be 50 or 60 lb., the limit of the size of the ingot must also be 50 or 60 lb.; in fact, the world was shown that more than one pot of steel might be discharged into the same ingot-mould; indeed, that hundreds of pots might be. Do not imagine for one moment I am depreciating this step. It was an enormous one, at the time when the production of fused steel involved the employment of the crucible. But, according to my judgment, the making of steel in crucibles is not so satisfactory a mode of obtaining uniformity in large masses as is either of the other two great systems of manufacture. I mean the Bessemer and the Siemens, the two processes which have changed the whole complexion of the iron industry. For years after 1862 we had papers at this Institution upon the question of steel rails, and we had it solemnly stated that the suggested economy in using these was an apparent economy only, for when interest was taken into account, having regard to the extra cost of steel over iron which must always prevail, it would never pay to employ steel rails, and the true function of steel in the permanent way would be to restrict its use to points and crossings. Now it would be difficult to induce any one to believe that an engineer was serious if he specified for wrought-iron rails, as it would be known that he would have to pay more money to obtain this inferior material. Important as the subject is, time compels me to refrain from further allusion to it, and forces me to conclude this head of my address with the physician's (Abernethy's) well-known advice to his patients, "Read my book," *i. e.*, my lecture at the Royal Institution, to which, however, I must add one word, and that is I must here refer to the important improvement made since the date of that address by the process of Messrs. Thomas and Gilchrist, by which it has been rendered possible to employ successfully, in the production of steel, iron derived from ores which prior to the date of this invention had been found wholly inapplicable for the purpose.

In the manufacture of pig-iron, improvement has been effected by increasing the dimensions of the furnaces, and (thanks to Mr. Cowper in the outset, followed by others) by increasing the temperature of the blast, and by the closer application of chemistry to the industry, by the total closing of the bottom of the furnace, and by the increased use of the waste gases. From these improvements an economy and a certainty of production have resulted leaving little to be desired; while it is to be hoped that another waste product—that of blast-furnace slag—will be converted to various useful purposes.

BRONZE.

I have varied the usual order by taking the iron age before the bronze. To revert to the bronze—the mysterious influences that a very small percentage of some material will exercise upon the quality of the great bulk of another material with which it may be united are well shown in the case we have been considering—that of steel—where a few tenths of one per cent. of carbon added to the iron suffice to change the iron into steel.

* Address of Sir Frederick Joseph Bramwell, F.R.S., on his election as president of the Institution of Civil Engineers, January 13, 1885.

We are not surprised, therefore, when we find that other metals may have their qualities improved, for many useful purposes, by judicious alloy; and in this way the metal copper, so long used in its alloyed condition of "gun-metal," has within the last few years been still further improved by alloying it with other substances, and thus making it into the now well-known articles "phosphor-bronze" and "manganese-bronze"—very useful materials to those of our members engaged in the construction of machinery. So closely allied to the consideration of the nature of a material is that of the means of producing it in the desired form, that one naturally passes thereto.

COMPRESSED STEEL.

As long as small masses had to be dealt with, and as long as those masses were of a plastic character, it was possible to successfully employ the hand-hammer, the sledge-hammer, and later on the steam-hammer; but with the increased dimensions of the main-shafts of engines and of the solid forgings for the tubes of cannon obtaining at the present day, and having regard to the fact that these are composed of steel, the operations of light steam-hammers are absolutely harmful, tending to produce internal flaws; and the blows of even the heaviest class of hammers are not so efficacious as is pressure applied without blow. I think the time is not far distant when (following the lead of Sir Joseph Whitworth) all steel in its molten state will be subjected to pressure, not with the object of making the metal more dense, but with the object of diminishing the size of any cavities containing imprisoned gases; if this is not done, then some other mechanical means will be employed to get rid of the cavities altogether, and thus to produce (without variations in the constituents of the steel) a casting that shall be practically, if not absolutely, free from blowholes, and so that such casting when afterward forged by pressure, and not by percussion, may be thoroughly trusted to contain no latent defect. One of the difficulties that was foreseen in the outset of the employment of steel for tires was the difficulty of welding the ends of a steel tire-bar after it had been bent into the hoop form. I was, I believe, one of the very earliest to suggest the making of tires in the hoop form, and so not only to avoid the cost and risk of welding, but also to avoid the waste upon each tire-bar arising from what was known as the "crop end." I read a paper on this subject before section G of the British Association at the Birmingham meeting in 1865, and I then prophesied that in a very few years from that time a welded tire would be unknown—a prophecy which has been amply fulfilled; but I also pointed out that, so far from its being the right way to set about the manufacture of a hoop by beginning with a straight bar, then bending it, and then welding it, the manufacture in the hoop form would be the proper one to adopt, even if the object were eventually to produce a straight bar, such as a rail, for if this were done the rolling would be continuous, and there would be no "crop end," no waste therefrom, and no fear that, in order to render the waste as little as possible, there would be retained at the ends of the rail—its most vulnerable parts—metal of an inferior character. In this same paper I showed that the right way of making boiler-shells and boiler-flues would be by the hoop system and by endless rolling, thereby avoiding the longitudinal seams, which, after the very best has been done that can be done, reduce the effective strength of the boiler-plate by one-fourth or one-third, and commonly reduce it by one-half. I will refer my hearers to vol. XX. of the *Engineer*, p. 200, where the paper and the accompanying diagrams are given.

STEAM BOILERS.

The subject of steam boilers brings one naturally to the consideration of that which still remains the great source of motive power—the steam engine. Here since 1862 it is difficult to point to any great substantive novelty, but these machines have been more and more scientifically investigated, and the results of such investigation have been practically applied, and have been attended with the anticipated advantages. The increase in initial pressure, the greater range of expansion, the steam-jacketing of the vessels in which the expansion takes place, have all led to economy, so that double-cylinder non-condensing engines are now currently produced which work with a consumption of only 2¼ lb. of coal per gross indicated horse-power, or 2·7 lb. per horse-power delivered off the crank shaft, equal to eighty-three millions of duty on the Cornish engine mode of computation; and when these high results are augmented by the employment of surface condensation, an indicated horse-power has been obtained for as little as 1½ lb. of coal, and it is commonly obtained, in daily work, for from 2 lb. to 2½ lb. But the engineer using steam as his vehicle in a heat motor still has to submit to the chagrin of seeing the largest portion of the heat pass away unutilized.

This defect has for years attracted the attention of scientific engineers. Indeed, we know that more than thirty years ago our lamented friend, William Siemens, devoted his great powers to the production of a regenerative steam engine by which he hoped to decrease this loss, but at that time he was not successful in producing a practical machine.

GAS ENGINES.

The labors of those who, following Stirling, have endeavored, by employing air as the vehicle of heat, to obtain better results, have succeeded in producing very economic machines, and machines of practical utility, but hitherto only applicable where small power is required. There is, however, another form of heat-motor which, while vainly essayed during fifty years, has within the last eight years come into common use, and the application of which in cases requiring anything up to 30 indicated horse-power is daily increasing. I need hardly say that I allude to the gas engine. By a happy change in the mode of burning the mixture, and of utilizing the heat thereby generated, the injurious shock of the early forms of gas engine, and the large consumption of gas which caused these earlier forms of engine to be discarded after trial, were obviated, a notable instance being in the engine propelling the fan that ventilates this room, which, after a short time, was pulled out and replaced by a hydraulic engine. According to the *Mechanics' Magazine* of August 10, 1866, page 87, the French engineer who tried a Hugon gas engine found that 74 cubic feet of gas per indicated horse-power per hour were required; this is now replaced by the 20 to 23 feet per indicated horse-power consumed in the engines of the present day. With the low price of gas commonly prevalent in England, this consumption does not cost more than some seven-eighths of a penny per horse per hour. I am aware it may be said that with coal, even at the London price of £1 per ton, I might use a steam engine having the low economy of 8½ lb. of coal per indicated horse-power per hour before I should be called on to spend seven-eighths of a penny for indicated horse-power per hour for fuel; you would be astonished to hear, however, that in an investigation instituted last year by the corporation of Birmingham, when considering whether they should approve of a proposal to lay down power-distributing mains throughout their streets, it was found, on indicating some six non-condensing steam engines taken indiscriminately from among users of power, and ranging from five nominal horse-power up to thirty nominal horse-power, that the consumption in one instance was as high as 27·5 lb., while it never fell below 9·6 lb., and the average of the whole was as much as 18·1 lb. This heavy consumption largely arose from a prevalent defect, one I have frequently pointed out, that of too great cylinder capacity; for unless a non-condensing engine is admirably designed, and made with the object of using very high expansion, there is nothing so wasteful as the employment of that which the buyer of an engine looks upon as an advantage—very great cylinder capacity; the result of such a construction being that the initial pressure of the steam, in the cylinder of the ordinary small power non-condensing engine, is not more than 20 to 30 lb. above atmosphere, a condition of things wholly incompatible with economy. But even assuming that the user of a gas engine were entitled to compare it with a non-condensing steam engine consuming only some 5 lb. of coal per indicated horse-power per hour, and demanding, therefore, at 1s. per cwt., only one half penny for the purchase of coal, this difference in cost is well repaid by the saving of boiler-space, of the wear and tear and of the renewal of the boiler, of the consumption of coal while getting up steam, and during meal times, and the saving in the engineer's or stoker's wages; and on public grounds there are the advantages of freedom from boiler explosion and of cessation of smoke production.

I have spoken of gas engines hitherto as though, like hot-air engines, they were necessarily restricted in their dimensions, but this is not so; engines are now being made to develop 50 horse-power; and further, be it remembered, that when used on a large scale, so that it would pay to have an attendant devoting his whole time, there is no need to work them with illuminating gas from the street mains; they can be driven by producer-made gas on Dowson's system, and when worked in this way, a pound and a half of "culm" will give one horse-power, and one lad is sufficient to manage a gas-producing apparatus of a size adequate to provide for engines developing 300 indicated horse-power. I ventured to say, at the meeting of the British Association at York in 1881, when giving a partial review of that which had happened in engineering in the fifty years from the foundation of the association, that unless some wholly unexpected improvement were made in the steam engine, those who lived to see the celebration of the centenary of the association in 1931 would find the steam engine had become a curiosity, and was relegated to museums, for I could not believe steam would continue to be the vehicle for transmitting heat into work.

THE SODA BOILER.

A motor has been recently tried where no fuel is employed directly, but where a boiler, being filled with water and steam under pressure, has its heat maintained by exposing caustic soda, contained in a vessel surrounding the boiler, to the action of the waste steam from the engine, the result being that as the moisture combines with the caustic soda, a sufficient heat is developed to generate steam and keep the engine working for some time.

The trials have been made with the motor for propelling a launch, and I believe with one for working a tramcar. It may be we have here a source of power, in a portable form, useful for the purposes I have mentioned, and for others analogous thereto. It hardly needs to be said fuel has eventually to be employed to drive off the moisture from the soda, and thus to bring it back to its caustic condition.

I cannot pass away from this brief allusion to heat motors without expressing my gratitude to those lecturers who addressed us on "The Mechanical Applications of Heat" last session, and especially to our member, Mr. William Anderson, for his lecture in that course on "The Generation of Steam and the Thermodynamic Principles involved." Let me tell those of you who do not already know it that Mr. Anderson has still three lectures to deliver out of a course of six lectures which he is giving at the Society of Arts on "The Conversion of Heat into Useful Work," and permit me to advise all those members of this Institution who can possibly do so to attend (as I hope to be able to do) the remainder of those most clear and instructive lectures.

SUN AND TIDE MOTORS.

There is one indisputable heat motor I have omitted, viz., that wherein power is obtained directly from the sun's rays. Attempts have been made during the last twenty-two years in this direction, but we enjoy so little powerful sunshine in England, and the question is still in such a thoroughly experimental stage, that I think I must not take up your time by any consideration of it. With respect to other motors, viz., those driven by wind or by water, not commonly looked upon as heat motors (although in truth there would be no such agencies without heat), but on these there is not time to say much; I will merely call your attention to the improvement in water-wheels in France, an improvement by which it is asserted that as much as 85 per cent. of all the energy residing in a low fall of water has been converted into power—a result due to the decreasing of the speed of the periphery of the wheel, and to the making of the buckets very narrow and of great depth. In turbines, also, there has been considerable development in these twenty-two years, and they now take their place as very efficient motors, possessing many advantages where, on the one hand, a very high fall of water has to be utilized, or where, in the case of a low fall, great difference in the working head, and in the level of the tail water, have to be provided for.

With respect to the power of the tide, I, for one, have been very much fascinated with the scope there appeared to be for engineering in utilizing tidal power, especially where there was a great ebb and flow, and I have on former occasions expressed some sanguine opinions as to the practical use that could be made of this source of power; but being called upon to look into the question, I found that as in these days of competition very few businesses needing motive power can allow their plant to remain idle for nearly half the working day, and that as there is an objection to remedying this condition of things by working, when possible, both during the night-tide and during the day-tide, this was an obstacle in most cases to the use of tidal power. Further, when it was sought to preserve continuity of action by providing a series of reservoirs, the outlay needed was so large that the mere interest on it would pay for the fuel for the steam engine. I am afraid, therefore, that, except for certain cases—such as pumping of water into a reservoir, or charging of so-called storage batteries, or matters of that kind not connected with ordinary manufacture—this source of power is not likely to compete commercially with heat motors until coal is very much dearer. The periodic intermittency being a sufficient bar to the employment of tidal motors, it is not to be wondered at that the (proverbial) uncertainty of the wind causes motors which have to be driven by it to be disregarded as substitutes for the steam engine. I have, however, said elsewhere I think it is well worth considering whether wind motors could not be employed as adjuncts to steam engines, diminishing the load upon them or laying them idle altogether, according to whether there was a light or a strong breeze blowing.

AERIAL NAVIGATION.

The uncertainty as regards the obtaining a sufficient breeze, which prevents the wind from being a trustworthy source of power, aggravated by the further uncertainty as to the direction in which the breeze would blow when it did come, has rendered the air, as a medium for navigation, even more untrustworthy. During the last few years, however, a new locomotive agent has been prominently brought forward—I mean a balloon capable of being propelled and steered, or, as it has been termed, a "dirigible" balloon. Many persons have fancied that it is impossible to propel a balloon through the air; but this, as I need hardly tell those who understand mechanics, is entirely a fallacy. The reasons why the early attempts to steer balloons failed were practical and not theoretical, and they have been removed by recent mechanical improvements. The first really successful effort was made by M. Henry Giffard, the ingenious inventor of the injector, all reference to which I have omitted, however, because of its being slightly anterior to 1862.

In 1852 this gentleman ascended in an elongated balloon propelled by a steam engine working a screw propeller; and he was followed twenty years later by M. Dupuy de Lome (the Government naval architect of France), who, however, used hand power. The speed through the air in these trials was about six miles an hour, and the steering power was fully obtained. Taking these and other experiments as data, my friend and fellow member, Dr. Pole, to whom I am indebted for the information on this subject, published in our *Proceedings* in 1882 a full investigation of the problem, which led him to believe that a velocity of 25 to 30 miles an hour might be attained; and since that time further trials have been made in France by Messrs. Tissandier, Renard, and Krebs, who, using electric power, have already accomplished half the predicted speed, with a promise of much further development when more experience has been gained with the practical details. I fear that the rapid and changeable motion of the medium in which balloons have to move will prevent this mode of locomotion from ever having a wide application, but there may undoubtedly be particular circumstances in which it would be useful, such, for example, as the exploration of new countries, or as the present Egyptian campaign. I strongly suspect that if our lively neighbors, instead of ourselves, had been invading the Soudan, they would long before this have had a "dirigible" balloon looking down into Khartoum. Let me refer all those who take an interest in this question to an earlier article by Dr. Pole, which was published in the *Quarterly Review* of July, 1875. This article is still considered a "classic" on the subject.

TRANSMISSION OF POWER.

Next to the subject of motors should have come (had I not been fed captive by a balloon) that which I am now about to mention, *i. e.*, the transmission of power. Taking this in the restricted sense of the transmission from a part of the machine to another, commonly with the object of varying velocity, one may point to the increasing use of multiple rope-driving gear, in lieu of belts, to inclined spur gear for diminishing noise, and to that kind of frictional gearing to which the name of "nest gearing" has been given. Here the frictional driver being acted on at the two opposing sides, strain is removed from the bearings, and the liability of one of the frictional wheels to stand still, and to be fatally injured by having a flat rubbed upon it, is avoided. In that very important branch of transmission wherein power is taken to long distances, however, we have the development of hydraulic transmission, as is evidenced by the fact of pipes being now laid down through our towns, for supplying water under the 700 lb. on the square inch pressure for motive power; we have companies authorized, if not at work, for laying down pipes to distribute compressed air; we have now, by reason of the improvement in gas engines, the ability to lay on power in every town illuminated by gas, which practically means every town and large village; and we have in New York and in some other cities of the United States, high pressure steam, conveyed in mains below the streets, to be used both for power and for heating, for which second purpose, however, it should be remembered the contents of a gas main are equally available. I will not touch upon other modes, except just to mention the rope system at Schaffhausen; but I think we may take it as clearly established that we are, day by day, becoming more alive to the benefit, where little power is required, or where considerable power is required, but only intermittently, of deriving that power from a central source.

WATER SUPPLY.

Under the heads of motors and of transmission of power (both of them, it is true, eminently subjects for the civil engineer) I have spoken of water, but there is another way in which water is used; the way with which engineers and the public are more familiar, viz., its employment for the supply of our towns, which I have not as yet mentioned. Except in the magnitude of the work and the excellence of the design, of which the new Liverpool waterworks now in progress may well stand as a typical example, there is not much to say as regards progress in those waterworks which are dependent upon storage. Indeed, there is nothing very marked to point to in these twenty-two years in the way of progress in pumping machinery. Having visited the United States and Canada twice within the last two years, and having seen the waste of water that takes place in both those countries (a waste which not only causes the mains to be incapable of keeping up the pressure under the excessive draught, but renders sources of supply insufficient which otherwise would be ample for years to come), I cannot but rejoice at the progress that has been made here in the matter of house fittings, by which waste has been greatly checked, and the risk of contamination that formerly existed with certain closet fittings is ended. This question of house fittings has always been a difficult one, and it becomes impossible to be grappled with by water authorities such as those in the United States and in Canada, *i. e.*, municipal authorities afraid of offending the voter. We owe it, however, to Mr. Deacon, the engineer of an English municipal water authority, that it is now possible to deal with the correction of household fittings at a minimum of cost, and, what is equally important, with a minimum of annoyance to the householder. By the employment of the waste-water meter, situated under the flagstones of the footway and controlling a group of houses, it is possible to find out the total waste in the whole of those houses, and on the mains supplying them; then to localize that waste so as to attribute its true proportion to the houses that are the offenders, and to attribute the proportion, if any, to the pipes of the suppliers of water. Having ascertained these facts, not only can the suppliers of water cure the defects in their pipe system, but they are enabled to cure the household waste, not by the expensive and annoying process of an inspection of the fittings throughout the whole district, involving the annoyance of say ninety householders whose fittings are in perfect order, to detect the ten householders whose fittings are in a reprehensible condition, but by the mere visitation of those ten who are in default, and who cannot therefore complain of the visitation. With respect to the purity of the water supply, this, although it relates to water, is so "burning" a question that I fear to touch upon it. I believe that in most of our towns the supply is satisfactory; but I do believe, in spite of the alarm raised by the suggestion of double mains, we might do well in many cases, where there is a pure but limited supply, to have a dual system of mains, and thus to distribute the pure water separately, and for potable purposes. I am not about to hold up the water supply of Paris as an example for us to follow on all points, but the Parisians at least have recognized the expediency of thus sorting their supply, when that supply is of varying quality and when the best of it is limited in quantity. In cases where there appears to be no thoroughly satisfactory source of water, the experience of the efficacy of iron purification, as practiced as Antwerp, does hold out very considerable promise.

ILLUMINATION.

Gas likewise has been alluded to under the heads of motors and of transmission of power and of heat, but I now desire to say a few words in connection with it under its more ordinary aspect, that of a distributed illuminant. In the year 1862 the price of ordinary coal-gas in London was from four to five shillings per thousand cubic feet; the illuminating power was such that 5 cubic feet of the gas burnt in a specified burner in one hour should give a light equal to twelve sperm candles, each burning 120 grains in the hour. At that time the consumer was, as it was facetiously called, "protected" by restricting the company to a maximum statutory dividend. Obviously, so soon as this dividend was earned, all incentive to improvement was removed. One of the few cases in which recent legislation relating to private companies supplying public wants can meet with the approval of the political economist, was that which a few years ago first recognized it would be well for the private company and for the public that the ordinary incentive of increased profit for increased exertion should remain, and that introduced in certain gas undertakings the "sliding scale." This provided for a normal price, and for a maximum dividend, but allowed the company to ratably increase this dividend in accordance with a decrease in price below the normal.

Under this wiser legislation, sixteen-candle gas is sold in London for as little as two shillings and tenpence per thousand cubic feet. But illuminating gas has to be considered by the engineer under two distinct heads: one, its manufacture and distribution; the other, its utilization. This last, it is true, is but to a small extent in the hands of those engineers who have the charge of the first. Considerable progress has, however, been made of late in illumination, largely, it is true, due to a greater liberality on the part of lighting authorities, and the use thereunder of multiple burners in street lanterns, but to a considerable extent due to that much more to be desired improvement, whereby a greater amount of light is obtained from the same volume of gas. The regenerative gas-burners, and other modes of burning, into which time will not permit me to enter, promise to largely increase (it is said, even to more than double) the candle power per cubic foot of gas burnt. Such improvement as this is undoubtedly of great moment, not only on the score of economy, but on the sanitary ground of diminishing the amount of products of combustion poured into a room in relation to the light therein afforded. It need hardly be mentioned that the decrease in cost and the increase in profits are largely due to the application of chemistry to this manufacture, by which application the former nuisance-creating by-products have been turned into sources of revenue and into fertilizers for our fields. I have also, in the most cursory manner, mentioned gas as a means of distributing heat; but a world should be said about those valuable improvements in gas-furnaces—I do not mean the Siemens furnace—which have enabled coal gas to be applied to the melting of even very refractory metals, by means of a most inexpensive plant. Nor have I spoken of those other applications, where, either burnt with coke (it may be of the very coal from which the gas itself was derived), or caused to raise incombustible bodies to incandescence, it forms the cheerful and smokeless substitute for a smoky coal fire, or is utilized for the purposes of domestic cookery. In this latter case, however, if absolute cleanliness and ventilation are not preserved, there will (as the unhappy traveler compelled to temporarily sojourn in the "limited" hotels of the present day finds to his cost) be one universal dirty gas-oven flavor impressed upon all his food, be it the homely leg of mutton or the lordly haunch of venison.

LIQUID AND GASEOUS FUELS.

Although it is quite certain that the first suggestion for using liquid fuel (notably tar, to aid in heating gas-retorts) must date long before 1862, yet the great development of the mineral oil industries since that date has led (and especially in Russia, in whose territory such enormous yields of oil are afforded) to the employment of this material as a fuel in furnaces and in steam boilers. Next to the infinitely divisible forms of gaseous and of liquid fuel comes, as I have said elsewhere, the dust fuel introduced by Mr. Crampton. In the use of any of these three forms, regularity of mechanical supply is a condition involved; and any one of these three, therefore, irrespective of all other considerations, is desirable because it is a means of dispensing with that most unsatisfactory form of labor, "stoking;" dispensing also with the production of smoke, and with the diminution of maximum effect attendant on the hand-feeding of coals, where the condition of the fuel in the grate and its temperature must be ever varying. Having regard to these advantages, which are to be obtained in using oil, and to the cheapness of the material in Russia, one is not surprised to find that there are lines of steamers on the Caspian worked entirely by liquid fuel, and that the same kind of fuel is used to fire the locomotives in many districts.

I have mentioned the improvement in small furnaces worked by illuminating gas; but I am not entitled to bring within my period the regenerative gas-furnace, that great invention made by our lamented friend Sir William Siemens, with whose name in this matter should be coupled that of his brother, Mr. Frederick Siemens. This latter gentleman, by a course of study, has recently discovered, and it is an interesting scientific fact, that so far from the heating power of the flame being increased by its confinement within narrow chambers, and by its being brought into contact with the material to be operated upon, such arrangements only diminish that power; and he has further found that this discovery can be usefully applied in practice by keeping the roof of a regenerative gas furnace at such a height above the hearth on which the materials to be heated lie, that the flame can traverse from one side of the furnace to the other, free of contact with the roof above or with the materials below. Very excellent economic effects and a high heat, it is stated, have been obtained by causing the outgoing products of combustion to give up their heat to the incoming cold fuel. I have seen such furnaces in operation, making steel by the hearth process, and it is the fact that the chimney has been without a trace of red glow within it.

The natural oils which are used as fuel, and to which I have referred, are rarely employed in their crude state as obtained from the wells; but they all undergo more or less refining before use. There is another natural fuel, however, which has been discovered in America, and within the last few years largely utilized—this is the gas obtained from wells in a manner similar to that in which the oil is obtained. It is a marsh gas of high calorific power, and is in certain parts of the United States being used very largely for domestic heating, for the heating of furnaces of every description, including those for the manufacture of plate-glass and of steel; it is also being employed for the manufacture of lamp or carbon black, and for the carbon points for electric lighting. It is stated that within a radius of 20 miles from the town of Pittsburg, taken as a center, there are twenty-five wells, each producing 3,000,000 cubic feet per twenty-four hours, and that the produce of the whole of the wells at present opened up is 100,000,000 cubic feet of gas per day. To my mind this is one of the most perfect fuels which can be imagined. It requires no preparation, but can be, and is, used in the same state as that in which it issues under a high pressure from the wells; it can be mechanically controlled with the greatest nicety, and when properly burnt is entirely free from smoke or similar defects. When employed in the Siemens regenerative furnace, the producer, which is necessary where coal is used, is entirely dispensed with.

AGRICULTURAL ENGINEERING.

Probably there is no function of the engineer in which the public feel their interest to be so immediate as when he is engaged in supplying to them their food. Prior to 1862 it is true that steam plowing and various cultivating and reaping machines were in existence; but they have been much developed since, and if the English farmer is to be saved while growing grain, it will be by reason of his availing himself of the labors of the engineer. Unhappily for the farmer, he has not the monopoly of the engineer's services, the products of whose skill are as fully appreciated for the cultivation of the enormous corn districts of the far West by the farmers there as they are in England. Again, unhappily for our farmers, the engineer, by his railways and by his improved steamships, renders it possible for the grain grown in the United States and in Canada to find its way to our markets at a cost for freight so trifling as not to equal that which, a few years ago, would have been paid for transit from one part of England to another. It would not be right to pass away from improvements in agricultural engineering without referring to that which is a distinctive novelty since 1862. I mean the fast-becoming-general combination with the reaping machine of string sheaf-binding apparatus. I am afriad I cannot claim for the engineer that recent introduction, the "silo." He is rapidly turning his attention to the improvement of the details, and is showing how mechanical appliances can be advantageously used in connection with them. By the aid of silos our grass crops may be saved in the green form, notwithstanding wet and unpropitious seasons; but those who still prefer sweet and sound hay may hope that the engineer will devise some practical mode of artificial drying, and thus enable them to obtain it even in the absence of the sun, and may also hope that the adoption of similar means will save our grain crops, although the harvest may be followed by steady and continued rain. But a question may arise, whether, except for horse feed, we need trouble ourselves about silos or hay, having regard to the fact of the great development since 1862 in refrigerating machinery, which renders possible the importation of frozen meat from Australia and from other countries. I hope for the sake of the English farmer that there will still be many who will be prepared to pay for English-grown beef and mutton, and for real milk and real butter, and that they will not be tempted by cheapness to substitute milk of condensation and butter of oleomargarine. But I hear the poor farmers are now threatened by a flood of steamboat transported milk from Holland. While on the question of food, the temptation is great upon me to refer to the wonderful improvements that have been made in "milling" since the year 1862; but I must refrain from this and from all other remarks upon the question of food, except to remind you that if the providing of food is one of the great social problems of the present day, another is how to get rid of sewage. This latter problem, however, has been so fully dealt with by my immediate predecessor, Sir Joseph Bazalgette, as to leave me nothing to say.

There are two other most important subjects involving large commercial interests, and in one of the subjects, at all events, great modern invention, upon which, fortunately, I need not say one word, as in respect of the first of these—electricity—I can refer you to the volume of lectures delivered here in 1883; and in respect of the second—tramways—I can refer you to the papers which, with the discussion upon them, have already occupied three evenings of this session. I see that our allotted time is already exceeded, and I am thus compelled to leave unsaid much which I should have liked to have told you, touching many things which almost every one of you must remember (each in his own special line of engineering) as being of general interest, and novel since 1862—railway brakes and signals, for instance; but the subject upon which I have undertaken to speak is so vast, that even with the severe limitation which, as I stated in the earlier portion of my address, I had imposed upon myself, I find omission is inevitable. Just a few words (and they shall be very few) about our Institution. You have done me the honor to elect me your president; and I trust it is unnecessary to assure you that during my term of office I will do everything in my power to uphold the dignity, the honor, the usefulness, and the prestige of the Institution; but my efforts alone will not be sufficient; I must ask you—each one of you—to help me, as failing this help the president is powerless. If each one of you, in his own way, works to advance our general interests by attending at our meetings, by bringing his quota of information on the subject which is under discussion to enrich our proceedings, by taking care that in speaking to give this information the time of the Institution shall not be wasted, either by bald repetition of platitudes or by fine oratory, and by remembering that his endeavour should be to add to the general knowledge in the simplest and most concise way possible to him, then I hope we shall be able to say at the termination of my period of office that the Institution has not retrograded, but that the ends and aim I am sure we all have in view have been materially enhanced. As I have already said, I will do all that lies in my power in the future as I have done in the past to arrive at such a consummation, and I must ask you—all of you—to assist me, feeling sure as I do that such assistance will be cheerfully and gladly rendered.

THE ARLBERG TUNNEL.

AUSTRIA is about celebrating the completion of the Arlberg Railroad, from Innsbruck over, or rather through, the Tyrolean Alps to the Lake of Constance in Switzerland—an enterprise undertaken by the Austrian Government chiefly, doubtless, to give a more direct connection with Switzerland, which is a large consumer of Austrian and Hungarian grain and other produce, but also to give it a connection with France and Western Europe generally, independent of Germany. It will, in connection with the Swiss railroads, form the most direct route betweeen Austria, and indeed all southeastern Europe, and southern France.

The railroad was one of the most difficult to construct that has ever been built, and a great deal of pains were taken in locating and designing it, nearly all the eminent engineers in the empire, apparently, studying and discussing it, and many submitting plans for it. It passes through some of the most magnificent mountain scenery reached by any railroad; and besides the usual concomitants of a mountain railroad—rock cuttings, bridges over torrents, and tunnels—galleries had to be provided for protection from avalanches, as on the Central Pacific Railroad. A bridge of 400 ft. span carries the road over the Trisana, 280 ft. above the torrent. Steep grades also were required, the line rising 2,152 ft. in fifteen and a half miles on the western side of the summit tunnel, requiring long grades, of 160 ft. per mile. On the eastern slope 132 ft. per mile is the steepest. The maximum curve is 7 deg.

The works are constructed for a double track throughout. The winter lasting seven months, and the temperature often falling to 30 deg. below zero, and the snow storms being frequent and severe, the line invariably follows the sunny slope of the valley.

The greatest engineering feature of the line is the great tunnel, the third longest in the world, and incomparably the most quickly completed. Commenced in June, 1880, it was pierced in November, 1883, considerably under the contract time, the contractors receiving a premium of 330 dollars a day. The bottom heading was cut first on the floor line, and enlarged. The top heading was cut first on the St. Gothard, but the quicker progress of the Arlberg Tunnel amply justifies the change. The rails at the summit in the tunnel are 4,372 ft. above the sea.

The following table, which gives some particulars of the four longest railroad tunnels in the world, shows what advances have been made in the art of tunneling, the time and cost having been both materially reduced. The enormous height of the mountains above the Alpine tunnels precluded the use of shafts, while

several shafts were used in the Hoosac Tunnel, thus increasing the number of working faces.

TABLE No. I.

The Four Longest Railroad Tunnels.

Name of tunnel.	Location.	Length in miles.	Years under construction.	Cost.	Cost per running foot.	Maximum advance heading in one year.	Date completed.
				dols.	dols.	feet.	
Hoosac.....	Massachusetts.	4¾	22	10,000,000	399	4,456	1876
Mont Cenis.	Savoy.....	7⅞	14½	15,000,000	356	5,395	1871
St. Gothard.	Swiss Alps.....	9¼	9½	11,175,000	229	8,235	1881
Arlberg....	Tyrolese Alps..	6⅞	5	7,300,000	154	11,775	1884

The lengths of the next longest railroad tunnels in the world are given below:

TABLE No. II.

Name of tunnel.	Where situated.	Length in miles.	When completed.	Cost.	Cost per running foot.
				dols.	dols.
Severn.....	England.....	4⅝	Not yet.	—	—
Standedge.....	"	3	1845	—	—
Woodhead.....	"	3	1845	1,026,000	65
Nerthe.....	France.....	3	1847	2,000,000	133

The first named tunnel passes under a wide tidal estuary, and dips downward toward the center from the ends. This is always objectionable, and in this case was especially so, large land springs having necessitated an unprecedented amount of pumping. The Severn tunnel has been eleven years under construction, but will probably be completed a few months hence.

The following table gives some particulars of the longest American tunnels. We are indebted to Mr. H. S. Drinker's exhaustive work on tunneling for most of the figures, which serve by contrast to show the enormous magnitude of the four tunnels given in the first table.

TABLE No. III.

Particulars of Longest American Railroad Tunnels.

Name of tunnel.	Location.	Length, feet.	Time in building, months.	Cost.	Cost per running foot.	When completed.
				dols.	dols.	
Baltimore...	Baltimore & Ohio.	6948	28	1,060,000	142	1873
Kingwood.		4100	30	724,000	176	1852
Sand Patch.		4725	96	375,000	80	1871
Bergen.....	N. Y., L. E. & W.	4588	36	800,000	182	1861
"	Del., Lack. & W.	4309	—	—	—	1877
Blue Ridge...	Col. & Greenville.	5865	—	—	—	1858
Blue Ridge.	Chesapeake & Ohio.	4392	—	498,000	114	1857
Great Bend.		6449	—	—	—	1872
Gallitzin.....	Pennsylvania.....	3612	30	—	—	1854
King's Mountain.....	Cincinnati So....	4000	—	360,000	90	1876
Musconetcong	Lehigh Valley....	4879	27	—	—	1875
San Fernando.	Southern Pacific..	6966	—	1,450,000	208	1876

The Arlberg Tunnel is nearly five times as long as the longest of the American tunnels, though only one-third longer than the Hoosac Tunnel.—*Railroad Gazette.*

IMPROVED ENGINE GOVERNOR.

IN the engine governor here illustrated two saucer-shaped shells or hollow disks fitted with appropriate blades work face to face in a casing filled with water. One of these turbines is driven by the engine, and the other oscillates, and works the throttle valve. The right hand figure shows the casing attached to the part of the steam pipe containing the throttle valve and the oscillating turbine in its working position. The middle figure shows the revolving turbine removed along with the casing door, through which its axle works. The left hand figure is a face view of the governor. The revolving turbine turns to the right when in its place, that would be to the left as shown removed and turned around.

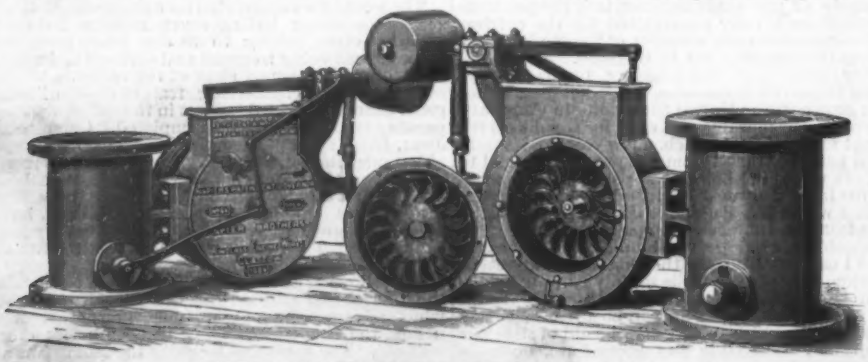
Calling the revolving turbine A, and the oscillating one B, then if turbine B is fixed while A is made to revolve to the right, the water in turbine A is thrown outward, forward, and sideways into the outer part of the blades of turbine B. The blades of the latter deflect the currents from a forward and sideways direction into an inward, backward, and sideways direction, which sends the water back into the inner part of the blades of turbine A. It is then again sent outward, forward, and sideways into turbine B, and so on. Hence there arises a cumulative action in this way. The faster the water enters turbine A, the faster it is delivered from it into turbine B, and the faster it enters turbine B, the faster it is delivered from it into turbine A, and so on. The water may, therefore, be delivered from the revolving turbine at a very much greater forward velocity than the rate at which the turbine itself is going, and there is no theoretical limit to that increase of speed. The shape and number of blades to get the best results have been obtained entirely by experiment, and after making several thousands of them.

The reversing of the motion of the water by the blades of the oscillating turbine gives it a great tendency to revolve in the same direction as the other one. This tendency is resisted by a chain attached to a pulley on the turbine, the other end of the chain being fixed to a lever connected with the throttle valve. The strain on the chain tends to shut the throttle valve, and it is resisted by a weight or spring tending to keep it open. When the strain on the chain exceeds that due to the weight, it shuts the throttle valve, and *vice versa.*

Governors have been made and worked with partial success on the principle of oil or water being forced by centrifugal action under a loaded piston.

In a remote degree the principle of the governor under consideration may be considered to be similar, but the practical results are very different. In the first place, from the cumulative action described a very small proportionate velocity of turbine is required to obtain a given power. In each turbine there are sixteen blades, and the average pressure on the blades is found to be four times that due to a stream flowing against them at the velocity of the circumference of the turbine, and, therefore, four times what could be produced on a piston by the centrifugal force derived from an ordinary centrifugal pump of the same diameter, and making the same number of revolutions.

Taking a pair of turbines 8 in. in diameter, which is found sufficient for working a 3 in. throttle valve, the blades in the oscillating turbine have each an area of 2 square inches, or 32 in. in all, so that the power over the throttle valve is equal to what would be produced by a centrifugal pump acting on a piston of four times 32 square inches area, or equal to a piston of 12 in. diameter. The travel of the end of the lever arranged for is 15 in., which corresponds with the length of stroke of a 12 inch piston to give an equivalent power. In the "Cat" governor the oscillating turbine, 8 in. diameter by 1 in. wide, weighing about four pounds, takes the place of such a piston and corresponding cylinder. The turbines do not require to work very close to each other, and are usually placed about one-eighth of an inch apart. It will thus be seen that the only part of the machine requiring to be kept tight is where the turbine spindle passes through the casing door. Leakage there is prevented by a collar on the spindle working against a facing to which it is kept by a spring The only part of the governor subject to wear is the turbine axle and its bearing, and these are made very long, so that they will last a great many years. A pair of 8 in. turbines at 200 revolutions produces a force of 36 lb. on the chain which works the throttle valve. The weight of the turbines is so small that inertia does not prevent their instantaneous action if a sudden increase of the speed of the engine takes place. As already observed, the shape of the blades used was adopted after making several thousand experiments. In trying them it was frequently found that a very minute difference in the shape or angle made a very material difference in the power. The water circulates among the blades only, and is almost stationary in the central space. This is shown by the fact that filling up that space makes very little difference in the action of the governor. It may be mentioned that it was christened the "Cat" governor from the quickness with which it prevents an engine from running away, giving the idea of a cat watching a mouse.—*The Engineer.*



THE "CAT" ENGINE GOVERNOR.

NEW ENGLISH FIRE ENGINE.

THE Watch Committee of the Liverpool Corporation have considerably increased the efficiency of their fire plant by the addition of two powerful steam fire engines from the establishment of Messrs. Merryweather & Sons, of London.

NEW STEAM FIRE ENGINE FOR LIVERPOOL.

The larger of the two new engines, the John Hughes, is the most powerful portable steam fire engine in the world; it is capable of pumping no less than 1,350 gallons per minute, and of forcing the water through a jet as large as a man's wrist to a distance of 300 ft. horizontally. Attachments are provided for working twelve streams of water simultaneously, each of which would more than top the highest warehouse in the city. The boiler is of Merryweather's improved "Field" type, with smoke tubes running through the steam space, and is fitted with side handholes. A new form of "Ramsbottom" safety valve is fitted to the boilers, and a "pop" valve is also supplied as additional security. A spiral copper feed-water heater is provided. The boilers, which are tested to three times their working pressure, are constructed of mild steel, which Messrs. Merryweather have used for the past twenty years for their steam fire engine boilers. There are three methods of feeding the boilers, so that in the event of one failing the others can be successively brought into play. The larger engine, the John Hughes, is of 100 indicated horse-power. It is direct in its action, working a pair of double-acting pumps, the two barrels, valve chambers, and all connections being cast in one solid piece. The slide motion is actuated by a pair of twisted bars, which work the small equilibrium slide valve.

The under part of the pump is supported by a new form of forecarriage, which obviates the bending of the frame, as hitherto, and renders the engine more compact by reducing the frame stays. This arrangement also makes the engine sufficiently light to be drawn by a pair of horses through most parts of the city. A screw brake is fitted to the engine, and is worked from behind. The engineer stands at the rear of the machine, so that he can act as stoker on the way to the fire. A patent crab is fitted to the pole, so that in the event of a horse falling it is instantaneously disengaged. The engine has two 9 in. steam cylinders, working a pair of 7 in. pumps, the stroke being 24 in. The capacity of the pumps is 13 gallons per revolution, so that if the engine is worked at the speed of 110 strokes per minute, the delivery of water will be 1,430 gallons per minute.

The smaller engine, the Rathbone, above illustrated, is of exactly similar construction, but of less size, the cylinders being 8½ in. diameter, and the pumps 6½ in. diameter, with a stroke of 18 in. Its capacity is 8·4 gallons per revolution, so that, if worked at the speed of 110 strokes per minute, the delivery is 924 gallons per minute. This speed is comparatively slow when compared with that of some fire engines, and insures the filling of the pump at each stroke. The Liverpool engines, as indeed all the direct-acting engines of Messrs. Merryweather and Sons' manufacture, will take their supply by the suction being screwed direct

on to a hydrant, the pressure in the mains thereby assisting the engines.

This type of engine not only forms an excellent land fire engine, but has also been extensively adopted for fixing on war vessels, tug-boats, etc. The Russian, German, French, Roumanian, and other governments, the dock authorities at Hull, Newcastle, Liverpool, etc., among many others, have adopted them. In Lancashire alone, Liverpool has five, Manchester three, and Oldham four, in addition to many others in private hands in the same towns. On the Mersey there are several tug-boats fitted with steam fire engines of the same type as those in the brigade, taking their steam from the boilers which work the propelling engines. The largest of these has a 10 in. steam cylinder by 24 in. stroke, working a 7 in. by 24 in. gun-metal pump.

At the trial of the engines, December 19, at the Albert Dock, the smaller engine, the Rathbone, steam was raised in nine minutes to the working pressure of 120 lb. on the square inch. The first trial of this engine was with 1⅝ in. jet, the stream from which quickly reached far above the summit of the high warehouses on the dock, notwithstanding the engine was working under a heavy lift of water from the dock, and there was a perfect gale of wind blowing at the time; next two jets of smaller diameter were attached, and the three worked with equally satisfactory results.

The John Hughes next got to work. Steam had been raised during the working of the Rathbone in order to save time, as the light would not serve much longer. The first jet used was 1⅝ in. diameter, followed by one of 2¼ in. diameter, which topped the warehouses with considerable force. To show what this powerful machine could do, this enormous jet was tried horizontally, and washed the building of an engine-house over 300 ft. distant, the wind still blowing in continuous gusts. It was then worked for the purpose of showing what could be done by throwing a number of jets simultaneously, and twelve lines of hose were attached with 1,200 ft. of hose, with ¾ in. nozzle at the end of each hose. Owing to the efficiency of the brigade in fire drill, there was not a hitch in the laying out of the hose or in connecting up. The power of the large machine was best displayed when the twelve jets were concentrated on to one spot, when the deluge of water was magnificent, and even to some of the onlookers alarming.—*Engineering.*

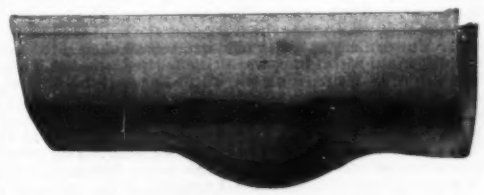
TRANSPORTING A MARINE BOILER.

WE illustrate below a marine boiler and trolley which were drawn from Thetford to Lynn in November last by a traction engine. The boiler, which is 11 ft. 6 in. diameter by 10 ft. long, weighing about 25 tons, was too large to be sent by rail, consequently Messrs. Charles Burrell & Sons constructed the trolley to convey it to Lynn. This trolley which weighs about 14 tons, is mounted on four wheels, the two hind wheels being fitted with India rubber tires, and the front axle being carried by a ball and socket joint. This, combined with the general construction of the trolley, enabled it to carry the boiler, even over the roughest roads, without any perceptible jar or vibration. The distance, which is about 36 miles, was accomplished easily in two days, although there were several long hills to climb, and the road in many places was very rough and stony. The wheels of the trolley being arranged to follow in a different track to those of the engine, over 5 ft. of the surface of the road was rolled; and instead of the engine and trolley doing any damage, they positively benefited the roads. The boiler was delivered under the crane on the dockside in Lynn, and then lowered in its place in the ship without any hitch whatever.—*The Engineer.*

THE EFFECT OF OIL IN BOILERS.

WE have often referred to the fact that the presence of grease or any of the animal oils in steam boilers is almost certain to cause trouble. Our illustration this month gives a better idea of the effect produced than pages of verbal description possibly could. It is from a photograph, and is nowise exaggerated.

The boiler from which the plate shown in the cut was taken was a nearly new one. It was made of a well-known brand of mild steel, and that it was admirably adapted to the purpose for which it was used is proved by its stretching as it did without rupture. The dimensions of bulge shown are four feet lengthwise of the boiler, three feet girthwise, and nine inches deep. The metal, originally $\frac{5}{16}$ of an inch thick, drew down to $\frac{1}{8}$" in thickness at the lowest point of the "bag" without the slightest indication of fracture.



The circumstances under which the bulge occurred may best be described in the words of the inspector who examined the boiler, and are as follows:

"Last Tuesday morning I was called in great haste to the —— works. Upon arrival I found one of the boilers badly bulged, and with twenty pounds of steam up. I could give no explanation until I had thoroughly examined the internal parts of the boiler. I gave directions for cooling the boiler, and ordered top man-hole plate to be loosened, but not to be taken out until my arrival in the afternoon, that I might see everything undisturbed. This was done. On my arrival I took out the man-hole plates in top of shell and front head, . . . and made an examination.

"I found that the boiler had been cleaned the preceding Sunday, and at that time a gallon or more of black oil had been thrown into it. Monday morning the boiler was fired up, and was run through the day at a pressure of 90 pounds per square inch. At 6 o'clock Monday night, the engine was stopped, the draughts were closed, and no more firing was done until 9 o'clock. Upon going to fire up at this time, the bulge was observed. From six to nine o'clock a pressure of only 40 pounds was carried.

"Upon examination, I found the entire boiler saturated with this oil."

This is almost certain to be the result of putting grease into a steam boiler. It settles down on the fire-sheets, when the draught is closed, and the circulation of water nearly stops, and prevents contact between the plates and the water. As a consequence, the plates over the fire become overheated; and under such circumstances a very slight steam-pressure is sufficient to bag the sheets. Unless the boiler is made of very good material, the plate is apt to be fractured, and explosion is likely to occur.

When oil is used to remove scale from steam-boilers, too much care cannot be exercised to make sure that it is free from grease or animal oil. Nothing but pure mineral oil should be used. Crude petroleum is one thing; black oil, which may mean almost anything, is very likely to be something quite different.

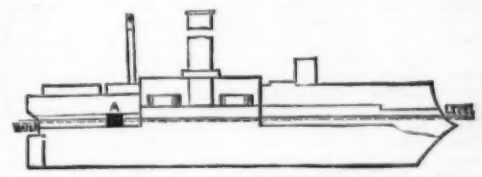
The action of grease in a boiler is peculiar, but not more so than we might expect. It does not dissolve in the water, nor does it decompose, neither does it remain on top of the water, but it seems to form itself into what may be described as "slugs," which at first seem to be slightly lighter than the water, of just such a gravity, in fact, that the circulation of the water carries them about at will. After a short season of boiling, these "slugs" or suspended drops seem to acquire a certain degree of "stickiness," so that when they come into contact with shell and flues of the boiler, they begin to adhere thereto. Then under the action of heat they begin the process of "varnishing" the interior of the boiler. *The thinnest possible coating of this varnish is sufficient to bring about overheating of the plates*, as we have found repeatedly in our experience. We emphasize the point that it is *not* necessary to have a coating of grease of any appreciable thickness to cause overheating and bagging of plates and leakage at seams.

The time when damage is most likely to occur is after the fires are banked, for then, the formation of steam being checked, the circulation of water stops, and the grease thus has an opportunity to settle on the bottom of the boiler and prevent contact of the water with the fire-sheets. Under these circumstances, a very low degree of heat in the furnace is sufficient to overheat the plates to such an extent that bulging is sure to occur. When the facts are understood, it will be found quite unnecessary to attribute the damage to low water.

This accident also serves to illustrate the perfection to which the manufacture of steel for boiler plates has attained. It would be an extraordinarily good quality of iron that would stand such a test without fracture. —*The Locomotive.*

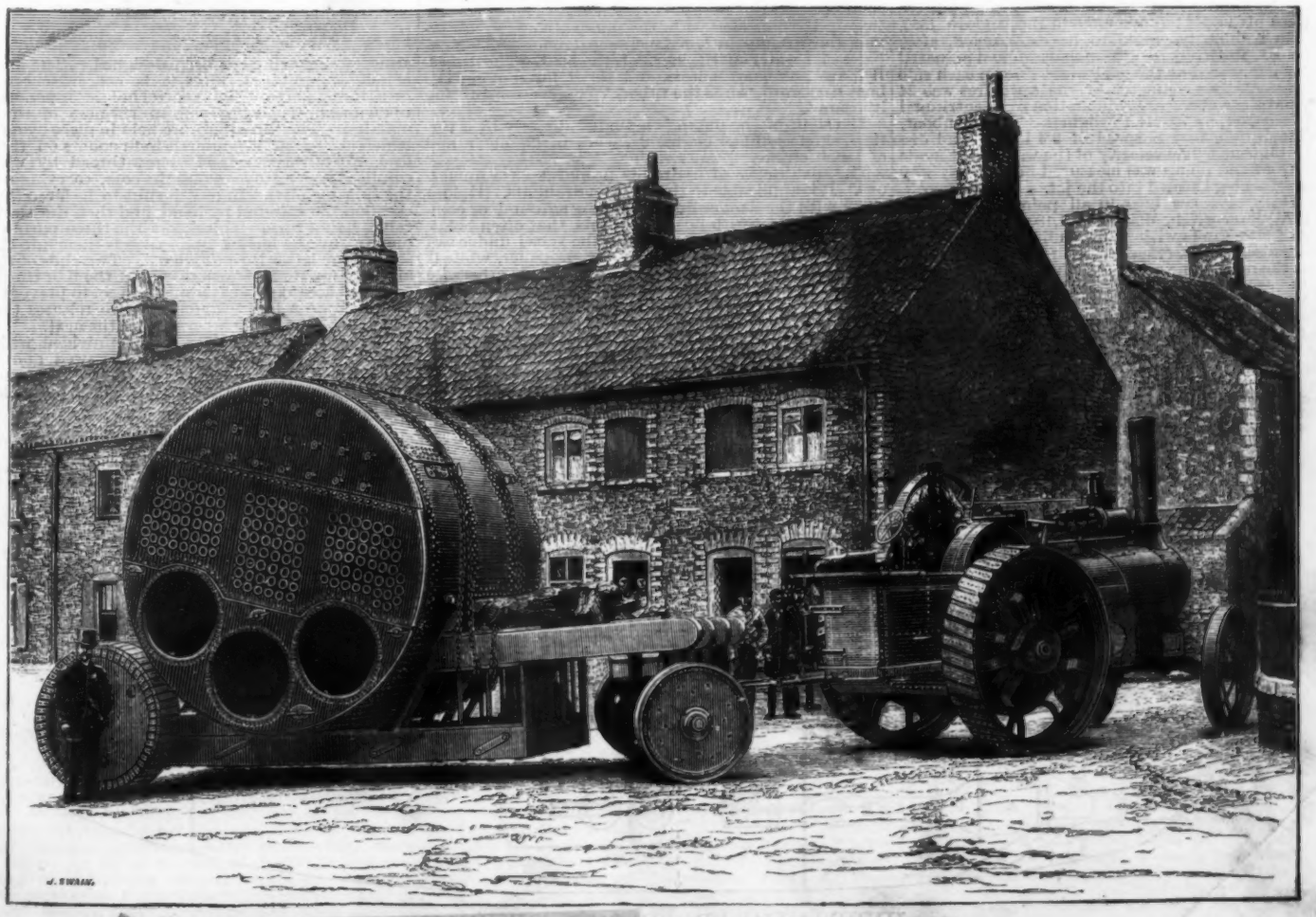
WATER CHAMBERS FOR REDUCING THE ROLLING OF SHIPS AT SEA.

MR. P. WATTS lately read a paper before the Institution of Naval Architects which referred to the use of a transverse chamber containing water as a means of reducing rolling. The accompanying diagram shows



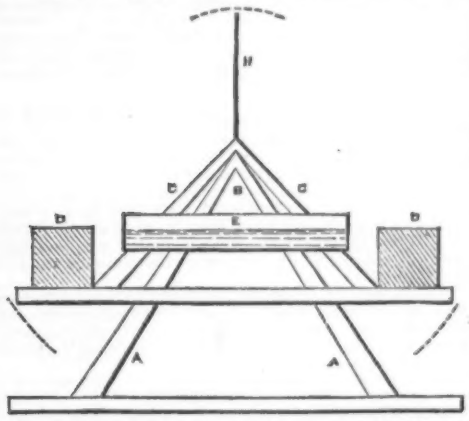
H.M.S. Edinburgh, with which a series of experiments have been made. The transverse water chamber is shown in section at A. It runs right across the ship from one side to the other. The water acts in the following way:

When the ship heels to port, let us say, the water runs down to the port side, and as it always moves after the ship has moved, it will all have heaped itself up at the port end of the tranverse water chamber just at



TRANSPORTING A MARINE BOILER BY ROAD.

the moment when the port side is beginning to rise again, and it will delay and retard the rising of the ship. The ship next rolls to starboard, and the water again follows the roll, and arrives just in time to check the rise of the starboard side. Let us suppose that a plank is balanced on a knife edge, and caused to rock like a child's see-saw. If now a man run along the plank in such a way that he will always reach that end of the plank which is lowest at the moment it is beginning to rise, it will be seen that considerable effort will be required to keep the plank rocking. The water plays the part of the man. It happens, however, that just the right quantity of water must be used, which means that the tank or chamber must be just about half full; if more or less, then it may arrive too soon or too late at the end of the chamber. Mr. Froude has carried out a series of experiments with Mr. Watts, and he showed a model in action which beautifully illustrated the theory. A A is a wooden frame with a knife



edge at B, on which is carried the second frame, C C; D D are two balance weights by which it can be leveled; E is a rectangular vessel with a front of glass, through which the behavior of colored water may be seen when C is caused to rock, as indicated by the curved dotted lines; H is a pointer.

The discussion which followed was opened by Mr. Liggins, who hoped that this device would be applied to merchant steamers to prevent rolling. Sir E. J. Reed, however, and several other speakers, regarded the scheme as of very doubtful value as applied to passenger ships, because the violent action of the water rushing from end to end of the chamber might, and certainly would in weak vessels, do a great deal of harm, and be productive of much danger. It is noteworthy that in the course of this discussion it was stated that there is now a tendency to make merchant steamers too wide for their depth.

HYDRAULIC PROPULSION OF SHIPS.

THE experiments on the hydraulic propulsion of ships undertaken by Mr. Maginot last year have again called the attention of engineers to a question that has been the object of numerous researches.

In fact, the first idea of this kind dates back to 1661. It was perhaps suggested by the well-known hydraulic tourniquet. Two centuries later (toward 1860) an effort was made at Seraing, Belgium, to apply centrifugal pumps to hydraulic propulsion. Serious comparative trials were made for the first time in England in 1866, when the Admiralty caused to be constructed, after plans by Mr. Ruthven, an armor-clad gunboat actuated by water jets placed at the load water line on each side of the vessel. The diameter of the apertures was 24 inches, and the water was set in motion by a centrifugal pump, actuated by 760 H.P. engines. This gunboat, the Water-witch, had a speed of 9·3 knots, and displaced 1,161 tons. The velocity of the water that made its exit from the pump was measured in a clumsy way by means of a log thrown into the jet.

The Viper, a screw boat in all points comparable with the Water-witch, displaced 1,180 tons, and had a speed of 9·58 knots with an expenditure of 696 H.P. The advantage, then, remained with the screw. These trials in the mean time attracted the attention of the Swedish government, which in 1878 made a comparison of two similar torpedo-boats—one a screw propeller, and the other a vessel moved by hydraulic propulsion. These torpedo-boats measured 58 feet in length by 10¾ feet in width, and gauged about 25 tons, with a power of 90 horses. The screw torpedo-boat had a speed of 10 knots. With a 78 H.P. turbine the hydraulic propeller had a speed of 8·12 knots.

The following year, Germany made some experiments with the Fleisher hydromotor without obtaining any satisfactory result. The steam acted directly upon the water. Two orifices, the action of which was intermittent, threw the steam in every direction. But this intermittent action produced a very bad effect upon the boat, and the expenditure of steam was enormous, and the speed obtained was but slight.

In 1882, the English Admiralty again took up the experiments that it began in 1866, and an order was given to Mr. Thornycroft for twenty torpedo-boats of the second class. It was decided to try the Ruthven hydraulic propeller upon one of these. The dimensions of the screw torpedo-boat were as follows: length, 63 feet; width, 7½ feet; draught, 3¼ feet; displacement, 1,289 tons. For the hydraulic propeller the engines were heavier, and the dimensions of the boat somewhat different. The length was 66 feet, the breadth the same, the draught 25 feet, and the displacement 14 tons. The water was expelled through a turbine running at the rate of 458 revolutions per minute.

The engines were of the compound type with surface condenser. The cylinders measured 12 and 8 inches in diameter, and the stroke of the piston was 12 inches. The suction pipe was under the hull, and at about the center of it. The orifices, which were situated on each side, just over the load water line, were 9 inches in diameter. They were capable of throwing the water forward, backward, and at right angles with the boat's axis. The pump discharged one ton of water per second with a mean velocity of 34 feet per second, and an expenditure of 167 H.P. The speed obtained was 12·6 knots per hour. The pressure of the jet was measured by means of a dynamometer. A plate 13 inches square was mounted at the extremity of a lever connected with the dynamometer, and was inserted into the jet at different points in the section of the orifice. The mean pressure was $\frac{8}{10}$ that of the central pressure. The engines of the screw torpedo-boat, which were much lighter, had cylinders 8 and 13 inches in diameter, and the stroke of the piston was 8 inches. They developed 170 H.P., and gave a speed of 17 knots per hour.

The coefficient of the jet's performance, that is to say, the ratio of its disposable energy to the effective work of propulsion, was found to be equal to 0·71. The coefficient of the pump's performance was 0·46. The Water-witch experiments gave 0·5 for the performance of the jet and 0·55 for that of the pump. It will be seen, then, that the jet's performance was raised by Mr. Thornycroft from 0·5 to 0·71.

In screw vessels the engine's performance is 0·77, and that of the screw 0·65, thus giving 0·5 for the total performance. Allowing the same figure, 0·77, for the performance of an engine actuating a pump, 0·46 for the performance of the pump, and 0·75 for that of the jet, we have 0·254 as a total. These figures show us that the jet gives a better performance as a propeller than the screw, and that the superiority of the latter over hydraulic propulsion is merely due to the feeble performance of the pumps. By increasing the effective duty of the latter it would be possible, then, to greatly improve hydraulic propulsion.

Things were in this state when Mr. Maginot began some researches with the pump of his invention. These researches attracted the attention of the French navy, and some experiments were performed in the presence of a state engineer.

The Nautilus, the boat used in these experiments, is shown in the accompanying engravings. It has the following dimensions: length, 46 feet, and width amidship, 6 feet. The mean draught is 1¾ feet. The Maginot pump, P, is 23 inches in diameter at its widest part. Suction is effected through the tube, A. The water coming from this pump is forced into a sheet copper tuyere, E, connected with the pump chamber and terminating in a nozzle, I, 8½ inches in diameter, debouching under water at the stern of the boat. The tubes, RR, are auxiliary motors, and serve for moving the boat backward, while the tubes, VV, serve for turning it around.

The shaft of the pump is actuated directly by a vertical, single-cylinder engine 8 inches in diameter and of 6 inch stroke.

The advantages of hydraulic propulsion are numerous. It is applicable to the smallest draughts. It does away with the danger due to running aground or coming into contact with floating objects, that often break screws. Finally, the running of the vessel under sail is in no wise interfered with by the propeller, while it is necessary to lift a screw through a well, or otherwise arrange it, in order to prevent a slackening of the speed, due to its resistance, when the vessel is running under sail.

As may be seen from the figures that we have given, the total performance of this system amounts to 0·49 in the Chalons experiments—a figure that nearly reaches that generally adopted for the performance of screw propellers.

The experiments above alluded to gave the following results:

Numbers of the Experiments.	1	2	3	4
Revolutions per minute.	240	357	425	518
Tm, Motive work in H.P.....	3·09	10·05	16·18	27
V, Speed of jet in meters per second.....	4·40	6·55	7·8	9·55
u, Speed of the boat in meters per second.....	2·46	3·30	3·83	4·22
$\frac{V}{u}$	1·8	2	2·04	2 28
Q, Discharge in liters per second..	202	300	355	435
Discharge per revolution.....	50	50	50	50
Performance of pump.....	0·60	0·60	0·66	0·80
" " jet.....	0·715	0·66	0·66	0·61
" total.....	0·425	0·40	0·435	0·49

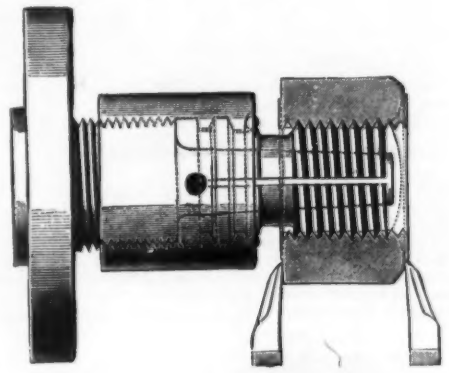
The values of V were obtained by special piezometric methods. The maneuvers were effected by means of valves. A 180° evolution *in situ* was obtained in 45 seconds, and a complete stoppage at the end of a run of about 6 miles, the speed being about 8 miles per hour.

If the Nautilus did not make very great speed during these experiments, it was due to her small dimensions and the imperfection of her form. The prow was too sharp in proportion to the length of the boat, and the after part lacked slenderness, while the body comprised a prismatic portion five feet long.

The experiments noted above have been very favorably reported upon by the engineer who was delegated to witness them. It is the intention of the experimenters to construct a much larger boat before long, provided with an improved propeller.—*Revue Industrielle.*

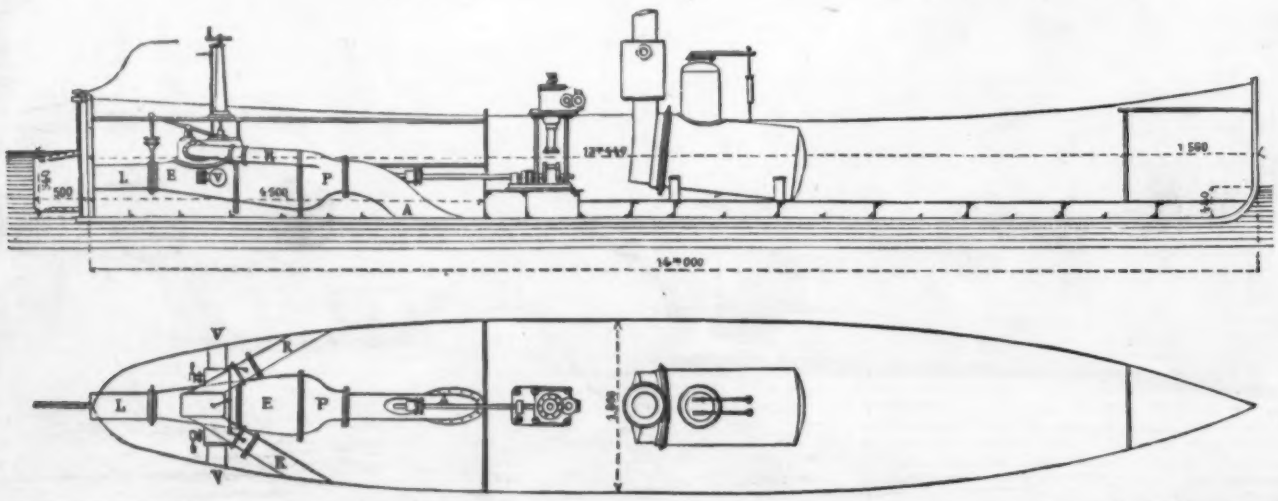
EXPANDING MANDREL FOR FACING NUTS.

To face nuts with accuracy it is necessary that they should be held firmly by a screw mandrel which fits tightly into the threads. But it is tedious work, forcing nuts on and off a screw that fits them so tightly that it will hold them against the pressure of the tool; and to avoid this, the expanding mandrel shown in the



annexed engraving has been designed. The mandrel is hollow, and is cut, after it is otherwise complete, into three parts. The central hole is taper, and fits upon a conical core fastened to the nose of the lathe mandrel. The three parts are held in place by a sleeve, which at one end has recesses to fit collars on the mandrel, and at the other end a screw thread by which it can be made to travel along the core, carrying with it the split mandrel. In use the nut to be faced is screwed upon the mandrel by hand, and then the sleeve receives half a turn. This draws the three parts of the mandrel up the incline, and expands them into the nut so that the latter is rigidly fixed. Two ends of the nut are then faced simultaneously, and the half threads at each end are taken out by a hand tool to prevent them burring up. A half turn of the sleeve releases the nut, which is removed to make way for the next.

The same core and sleeve can be provided with several sizes of split mandrels, both screwed and plain, and suitable for many classes of work. The mandrel is made by Messrs. H. B. Barlow, Jr., & Co., Manchester, England.



HYDRAULIC PROPULSION OF SHIPS.

IMPROVED ANEMOMETER.

THE engraving given above represents a most convenient form of an instrument that has frequently to be used by mining and mechanical engineers for ascertaining the velocities of currents of air, as in the ventilation of mines, draughts of chimney, velocities of fan draughts, etc. The instrument is called an anemometer, and, as usually made, is a mos inconvenient and troublesome thing to deal with, requiring to be carried about in a wooden case. The convenience and portability of the anemometer we now illustrate will be at once recognized. It is made in the form and about the size of a watch, and when the two lids are closed on the body, it cannot be distinguished from one. Of course it may be carried about in the waistcoat pocket in the same way as a watch. When the two lids are open, as is represented, they form a base upon which the instrument can stand when placed in a current of air, the velocity of which it is required to ascertain. The check spring in the pendant upon being pressed by the finger stops the movement of the vanes at the end of the period necessary for making the observation, when the velocity of the current in feet per minute can be read off from the dial. To do this, however, it is generally necessary to note the dial records before using the instrument, and afterward to take this figure from that obtained after the observation was taken. On the dial the outer circle records the velocities in

BIRAM'S ANEMOMETER.

feet up to 100, and the smaller circle continues the enumeration up to 1,000 ft., each figure on this circle representing 100 ft. or once round for the hand of the larger circle. In making this instrument every care has been taken to reduce friction to a minimum and to obtain a sensitive action, as will be seen when we state that the spindles in the counting arrangement are jeweled with agate at four points. Altogether, Biram's anemometer, made by A. Morrison, Manchester, seems to be a well-made, handy, and compact little instrument.

DAVIS' ANEMOMETER.

BY holding the instrument in the current of air to be measured for a few seconds, it correctly indicates feet per second. The anemometer is exceedingly portable, being only 4 in. in diameter. In general appearance it very much resembles the Biram anemometer, which was brought out by the same firm nearly forty years ago, and is now in general use. Most colliery managers and engineers acknowledge the difficulty and inconvenience experienced in using the Biram anemo-

DAVIS' ANEMOMETER.

meter, which necessitates the use of a watch; and, unless one is assisted by a man to carry his lamp, he has to hold his anemometer, watch, and lamp. The new instrument—Davis' anemometer—dispenses with the use of a watch or timer, and also of a lamp carrier; and, when held up in the circuit of air, without loss of time indicates the velocity per second. This instrument—like the Biram—is, in use, held up with its back facing the current of air to be measured. When the vanes have revolved for a few seconds, on the pressing of the spring button at A the large hand indicates feet per second. Should the velocity be such that the hand travels more than one revolution, then the inner circle of figures is read. The small hand shows whether the outer or inner circle should be read. Every instrument is, we are informed, graduated at each unit by actual experiment; no allowance has, therefore, to be made for friction. Great accuracy is attained in reading the indications, and the instrument—although a scientific one—is so constructed that an inexperienced overseer can easily manipulate it. Made by Davis & Son, Derby.

ROSENTHAL'S GALVANOMETER.

ALL the galvanometers now in use, such as those of Thomson and Wiedemann, present the same disadvan-

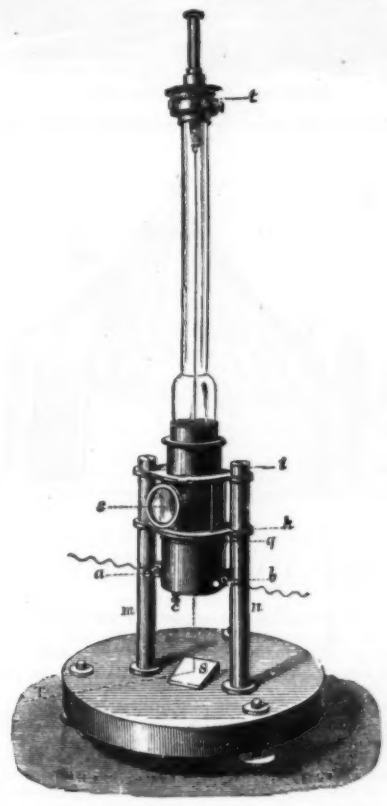


FIG. 1.

tage—the arrangement of the spirals is very unfavorable, so that, in order to increase their sensitiveness, it becomes necessary to considerably increase the number of the wire's revolutions, thus increasing the resistance of the apparatus. It often becomes necessary, even, to add to a bobbin that is to serve for different experiments a series of bobbins capable of being substituted for one another, according to the requirements of the experiment. Thus Wiedemann's compass always requires three pairs of bobbins, one for thermo-electric currents, one for hydro-electric ones, and one for physiological experiments. Through a new arrangement of the spirals Mr. Rosenthal has succeeded in constructing an apparatus that has a resistance of but 30 ohms, and that far exceeds in sensitiveness all the instruments hitherto known. The apparatus presents the further advantage of being capable of serving for electro-physiological experiments and for thermo-electric currents. The utility of so great sensitiveness is especially apparent in the methods of reduction to zero, such as the measurements of resistances by the aid of Wheatstone's bridge, and the measurements of electro-motive force by Poggendorff's compensation method. The use of this instrument is very simple and its price very moderate. Figs. 1 and 2 show the arrangement of the apparatus. Fig. 1 gives a general view of it. To a marble base, T, provided with three leveling screws, *e*, *f*, *g*, are adapted two columns, *m* and *n*, which support the disks, *i* and *k*. To the disk, *k*, is fixed the deadener, *d*, held by a screw, *q*, whose extremity enters a groove, *u* (Fig. 2). At *a* and *b* are terminals that communicate with the extremity of the bobbins.

Between *i* and *k* there is a movable case containing

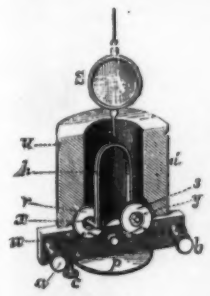


FIG. 2.

ROSENTHAL'S GALVANOMETER.

the mirror, and formed of two half-cylinders. To the disk, *i*, is screwed a tube, A, which contains the suspension thread, and which is surmounted by a revolving piece to which the thread is attached.

The arrangement of the essential parts of the instrument is shown in Fig 2. The needle is a small horseshoe magnet, *h*, to the polar ends of which are fixed two horizontal curved appendages, *x* and *y*. These latter, which are cut from the same piece as the magnet, form the poles upon which the deflecting action of the bobbin is directly exerted. As the distance between these poles and the bobbins is as small as possible, the action is as efficient as can be. The polar appendages are arcs of a circle whose center is in the axis of rotation, and they freely traverse the bores of the two bobbins, *r* and *s*. Each of these latter consists of 200 revolutions of $\frac{1}{10}$-inch insulated silver wire wound upon ivory spools that rest in cavities in an ivory support, *w*, to which the terminals, *a* and *b*, are fixed. This support has the form of a parallelopiped, and engages with two longitudinal slits in the copper deadener. It is held therein by a glass plate, *p*, which, through three small screws, *e*, is fixed to the deadener and closes it at the bottom. The latter (the deadener) is a large hollow copper cylinder.

The magnet supports the silver mirror, *s*, at its lower part, and both are suspended by a cocoon fiber.

The manner in which the apparatus is mounted may be readily seen. The deadener must be so placed that the slit with which the bobbin-support engages shall make an angle of 45° with the line of the poles.

In order to facilitate the manipulation connected with the regulation of the instrument, there is placed upon the marble base a mirror, S; which reflects the whole interior of the apparatus in the direction, T.

The dimensions of the instrument are as follows:

Total height	18 inches.
Height of tube	10 "
Height of deadener	1·5 "
External diameter of deadener	1·5 "
Diameter of cavity of deadener	0·8 "
Height of magnet	1·0 "
Weight of magnet and mirror	60 grains.
External diameter of bobbins	0·46 inch.
Thickness of bobbins	0·12 "
Diameter of bore of bobbins	0·2 "
Resistance of the two bobbins	39 ohms.

In order to give an idea of the sensitiveness of the instrument, Mr. Rosenthal cites the following data: (1) Without compensating magnet (of Hauy), a deflection of 0·04 inch is equivalent to $54 \cdot 10^{-10}$ amp., the distance from the scale to the mirror being nine feet. (2) With a compensating magnet and the same distance of the scale, a deflection of 0·04 inch is equivalent to $12 \cdot 10^{-11}$ amp.

The current from a German silver thermo-electric pile due to a difference of 10° C. temperature at the solderings, and traversing 1,000 ohms, gives a deflection of 4·8 inches, the scale being 9 feet from the mirror. The inventor has verified the ratio of the slight deflections to the intensities. To this effect, he placed a galvanometer in a derived circuit taken from a platinum wire 3·28 feet in length, stretched in a straight line. The principal circuit was formed of one Leclanche element of 6,600 u. s., and of the platinum wire. In causing the distance between the two points of derivation to vary upon the platinum wire, deflections of the galvanometer proportional to such distances were obtained. The following data are given by Mr. Rosenthal:

Distance of the Points of Derivation on the Rheostat.	Deflection on the Scale.		
			Means.
10	6·0	6·0	6·00
20	13·0	12·0	12·50
30	18·0	17·0	17·50
40	24·0	24·0	24·00
50	29·5	30·0	29·75
100	59·5	61·0	60·25
200	118·0	122·0	120·00
300	176·0	184·0	180·00
400	240·0	245·0	242·58
500	296·0	305·0	300·50
600	355·0	367·0	361·00
700	415·0	432·0	423·50
800	476·0	495·0	485·50

The concordance is quite sufficient, when we take into account the imperfection of the experiment. The errors do not exceed the limits that ought to be expected, with the experimental arrangement that the inventor chose.

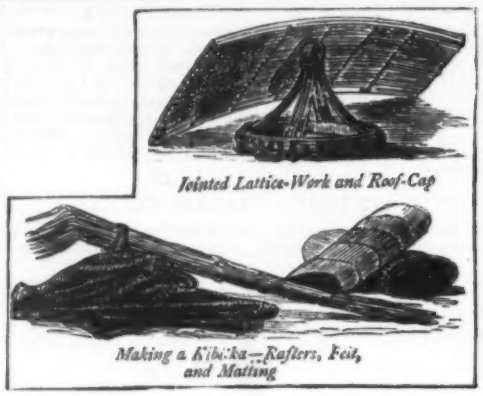
Mr. Rosenthal has made a series of measurements of resistances in order to ascertain the degree of approximation that the instrument is capable of reaching, and has found that it is possible to estimate variations of 0·005 per cent. The instrument is peculiarly convenient for electro-physiological experiments, and in these is capable of rendering genuine service.—*La Lumiere Electrique.*

BORAX FOR INTERNAL USE.

DE CYON, following Dumas, maintains that borax, unlike other antiseptics, is perfectly harmless even in doses of as much as 15 grammes in the course of a day. Besides the importance of this fact in regard to public alimentation, the author considers it has a great medical interest. He believes borax taken internally in times of epidemics would prove of great hygienic value. In 1879, when the plague broke out in Russia, he went to St. Petersburg, and persuaded the Imperial Medical Council to recommend the use of this substance in the affected districts. This recommendation was made in a meeting of the Council on February 19, 1879, under the presidency of Dr. Pelikow. The end of the epidemic, however, prevented the proof of the value of borax on that occasion. Since then M. De Cyon asserts that he has had frequent opportunities of testing the medicinal virtue of borax. He urges its employment in the districts invaded by cholera, and asserts that the workmen in borax factories have always been remarkably preserved from attacks, even when they have been in the midst of the disease. Thus in Italy, during the violent epidemic of 1864–65, none of the workmen in the seven factories at Lardarello was attacked, although in a village only three kilometers distant a third of the whole population was swept away. M. De Cyon recommends it to be taken in quantities of five to six grammes per day, and believes that it destroys the microbes not only in the intestinal canal, but also in the blood.

THE AFGHAN KIBITKA.

THE houses of the Turcoman nomads are called "kibitkas." They are by no means the rough and clumsy affairs one would suppose from their outside appearance, but are really neat and delicately made structures, recalling in some of their parts a child's toy or puzzle. The latticework of the walls is so jointed as to shut up like an expanding flower-pot stand. "The kibitka," says the *Times* correspondent at Bala Murghab, "is a dome-shaped frame work of latticework, covered with layers of felt, the number of layers being in proportion to the severity of the weather. The walls for about six feet of their height are vertical, and then the dome rises to a height of twelve or fifteen feet. A felt cap fits on a hole in the center of the roof, which lets in the light—for the kibitka has no windows—when it is fine, and lets out the smoke when a fire is lighted on the ground underneath. The floor is generally spread with carpets of choice patterns, rich colors, and velvety softness, worked by the daughters of the kibitka; on the walls, too, hang camel bags of the same rich carpet work. The great advantage of a kibitka is that in a few hours you can strike, pack up, and load it on a camel and be off."—*London Graphic.*



Jointed Lattice-Work and Roof-Cap

Making a Kibitka—Rafters, Felt, and Matting

Since the action of filtration is exerted from within outwardly, salts of various kinds may be put into the interior (so as to obtain artificial mineral waters), or special materials for decolorizing liquids, or, finally, ice (even impure) for cooling the water in summer.

A simple apparatus is capable of filtering from 9 to 10 gallons per day, according to the pressure of the water. By modifications in its proportions and construction a larger quantity of water might be filtered.—*Le Genie Civil.*

CEDRON SEED.*

By DR. H. STIEREN.

Simaba cedron, Planch. Nat. Ord., *Simarubaceæ*. Syn.—French, *Cedron*. German, *Simabasamen*, *Cedronbohne*, *Cedronsamen*.

The tree furnishing this seed is indigenous to New Granada and Central America. Hager states that the *Simaba ferruginea*, St. Hil., a native of Brazil, also yields the seed.

HOISTING ON THE ROOF CAP.

FRAME COMPLETE: PUTTING MATTING ROUND THE WALLS.

THE FINISHED EDIFICE.

THE AFGHAN KIBITKA.

THE AERIFILTER.

WATER for drinking purposes should be as free as possible from all impurity, whatever the source. In boiling it we destroy all the organisms and germs that it may contain, but we at the same time deprive it of its gases, so that it becomes insipid and indigestible. So it is generally preferred to filter it. Up to recent times it has been the practice to pass it rapidly, under the action of its own weight, through spongy bodies that free it from material visibly in suspension; but this merely clarifies it without completely purifying it. Since Mr. Pasteur's labors have become known, it has been seen that it is indispensable to have water free from microbes. Among filtering materials, porous porcelain is one of those that gives the best results, and this is the one used in Mr. Pasteur's laboratory.

Mr. J. Mallie, a civil engineer, has just patented a new filter which utilizes the pressure of the city water to force the latter to ooze through porcelain, which retains in its close and imperceptible pores all organic germs, those vehicles of endemic and epidemic diseases. His apparatus consists of a porcelain filter, properly so called, which the water enters under pressure through a tube affixed to a cock. This filter is inclosed in a thick earthern vessel, which is affixed to a metallic support by a bayonet catch, and which serves to protect the porcelain and collect the purified water. The apparatus is made tight through rubber washers of circular or elliptical section, which take the exact impressions of the grooves in the upper part of the porous vessel and the adjacent faces of the socket and cap of the apparatus. This forms a very tight joint without exerting a stress that might break the neck of the porous vessel.

The lower part of the entrance tube is narrowed, and serves as a seat for a conical valve carried by a rod that rests upon the bottom of the filtering vessel. In case of a breakage of the latter, the valve closes. Owing to the automatic operation of this safety apparatus, no accidental flooding and no discharge of unfiltered water are to be feared. The cup constitutes a true reservoir that contains a certain quantity of compressed air, which, thanks to its elasticity, tends to prevent breakages that might occur through the ram strokes of the water under pressure. Besides, the air dissolves in the liquid, and so the latter, on making its exit from the filter, is charged with minute globules of it; hence the name "aerifilter" that the inventor has given the apparatus.

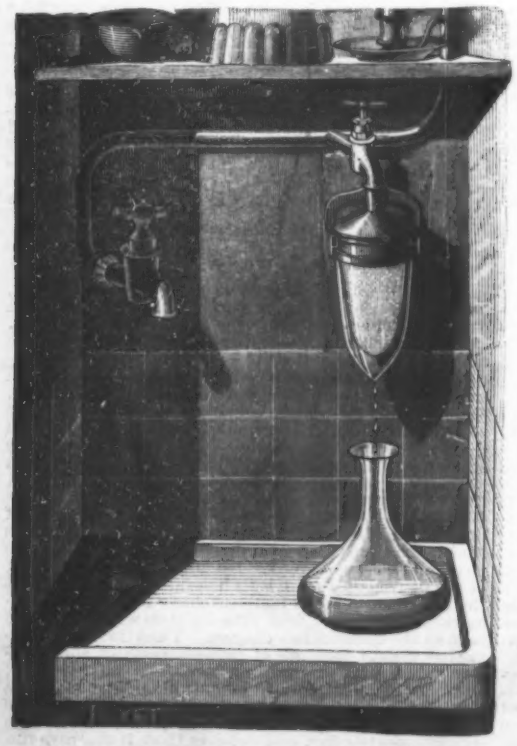


FIG. 1.—AN AERIFILTER FIXED OVER A SINK.

FIG. 2.—DETAILS OF THE AERIFILTER.

The simaba cedron does not exceed a height of 6 meters, with a trunk of from 15 to 25 centimeters in diameter. The glabrous leaves, 60 centimeters and more long, composed of twenty and more leaflets, oftener alternate than opposite; leaflets sessile, 10 to 15 centimeters long, acuminate, oblique or unequal at the base, penninerved. The common or general petiole is cylindrical, terminated by an uneven leaflet. Clusters of 60 and more centimeters length are close together, ramose, covered with a short down, reddish, and velvety. With a small calyx in shape of a cup, obtusely five-toothed, the corolla is composed of six linear, spread-out petals, of a pale and cottony brown externally. The very voluminous fruit, solitary through the abortion of the other carpels, is a drupe of oval form, obliquely imperfect at the top; the fleshy part of the fruit, which appears not to have been very soft, surrounds a horny endocarp. The seed is sole, voluminous, dangling, covered with a membranous tegument, while the cotyledons are very large, fleshy, and white in the recent state. It is those isolated cotyledons which constitute the article of commerce, and which are from 3 to 4, rarely 5, centimeters long, 15 to 20 millimeters broad, of an elliptic form, curved a little on one side, convex externally, flat or very slightly concave on the internal surface, with a small seam at the top. By drying they have turned into a yellow color, often kind of dirty and blackish looking externally, and lighter yellow internally. Without any particular odor, they are possessed of a very bitter taste reminding of quassia, and contain through their whole substance a large amount of starch (from 33 to 36 per cent.), 8 per cent. of a solid fat scarcely soluble in alcohol, 33 to 35 per cent. albuminous matter, about 10 per cent. of a soft resin, 8 to 10 per cent. gum, and 2 to 3 per cent. of a crystallizable, very bitter substance, which has been named *cedrin* by Levy, who discovered it as long ago as 1851.

Medical Properties and Uses.—The seeds are prescribed by the physicians of New Granada as a fever medicine, and are also used internally and externally as an antidote for the bite of poisonous animals. The natives of New Granada and Central America never venture into the forests unless supplied with a few of the seeds, which are cut into thin transverse sections, and these are applied to the wounds. Fever patients cut the seeds into pieces the size of a pea, which they swallow gradually, principally so during the apyrexia. Cedron is stated to have been used successfully when quinine and arsenic failed to cure, and it is also employed in diarrhœa and colic. Being so very bitter, it has been recommended to administer the drug in pill form, made from the dried extract, 100 grains of the seed yielding 30 to 33 grains of the watery, and a little more than half that quantity of the alcoholic, extract. Cedron is also highly esteemed for the prevention of hydrophobia, in spasm of the stomach and bowels, and dyspeptic affections. Although the usual dose in Central America is one or two grains, Dr. Purple, of New York, who extensively employed the drug already thirty years ago, pronounces the doses mentioned too small, and that from any ordinary quantity no fear of injurious consequences need be entertained. He gave from 10 to 30 grains of the seeds every four hours, and found that, though in very large doses they may produce griping and diarrhœa, these effects are easily controlled. He has come to the following conclusions regarding their therapeutic action:

That cedron possesses decided antiperiodic properties, and is, therefore, applicable in the treatment of periodic diseases.

That it is less likely than quinine to produce the aggregate of encephalic or neuropathic phenomena induced by overdoses.

That it may, in large doses repeated often, produce griping of the bowels and even diarrhœa; but that these conditions are easily controlled by appropriate medicaments.

That, as a remedy in intermittent fever, it possesses

*From *A New Idea*, November, 1884.

properties in many respects equal to quinine, and in most cases is equally adapted to the treatment of this disease.

That, in the treatment of yellow fever, it does not appear to possess any particular advantages over quinine, but, nevertheless, is equally adapted to fulfil, the indications which call for the use of this latter remedy.

That it possesses marked tonic properties, and deserves a prominent place in this classification of the materia medica.

That in chronic dysentery, diarrhœa, dyspepsia, and all stages of the stomach accompanied with impaired or difficult digestion, its use will be found to be attended with benefit.

Dr. Guier, of Costa Rica, has seen cedron successful in curing the bite of a poisonous serpent, and has used it effectually in cholera morbus, colic, and neuralgia of the face, while in the hands of Dr. Thompson, of London, it has proved efficient in the treatment of gout. M. Heran states that he has employed the remedy in eight cases of poisoning, and that his mode of using it was to administer 5 or 6 grains with a spoonful of brandy, and to dress the bite with the tincture; and that he had rarely occasion to repeat the dose to effect a cure.

In a note on cedron seed from the United States Consulate, Livingston, Mr. James Frederick Sarg says:

The cedron is highly prized here, nobody going without a seed, which is used against ague and fever, poisonous snake-bites, spasms, etc., and is the most effective cure for toothache that I know of. This seed sells here for twenty-five cents apiece."

ON THE LIQUEFACTION OF GASES AND OTHER EFFECTS OF EXTREME COLD, AND ON SOME PHENOMENA OF HIGH TEMPERATURE.*

By J. J. COLEMAN, F.I.C., F.C.S.

WITHIN the last seven years it has been proved that all gases, including atmospheric air, can be reduced to the liquid or solid state by reducing their temperature sufficiently low, the operation being in some cases assisted by compressing them so as to approximate their particles before subjecting them to the influence of extreme cold. Theoretically, it is to be inferred that the abstraction of heat is much more effectual than compression, for in proportion as the absolute temperature decreases they decrease in bulk, so that before absolute zero is reached (which on Fahrenheit thermometer is —461°, or Centigrade thermometer —273°), they should either liquefy or become solid. Although Faraday employed compression as well as cooling in his earlier investigations upon the liquefaction of gases, he appears to have thoroughly understood the conditions upon which success could be obtained, as in his paper read before the Royal Society in 1845 he remarks:

"The following gases showed no signs of liquefaction when cooled by a carbonic acid bath *in vacuo:*

Hydrogen	at 27	atmospheres.
Oxygen	27	"
Nitrogen	50	"
Nitric oxide	50	"

"The difference in the facility of leakage was one reason of the difference in the pressure employed. I found it impossible from this cause to raise the pressure of hydrogen higher than 27 atmos., by an apparatus that was quite tight enough to confine nitrogen to double that pressure.

"M. Cagniard de la Tour has shown that at a certain temperature a liquid under sufficient pressure becomes clear transparent vapor or gas, having the same bulk as the liquid. At this temperature, or one a little higher, it is not likely that any means of pressure, except perhaps one exceedingly great, would convert the gas into a liquid. Now the temperature of the carbonic acid bath *in vacuo*, viz., 166° below zero Fahr., *low as it is*, is probably *above* this point of temperature for hydrogen, and perhaps for nitrogen or oxygen."

In the same paper Faraday makes the further remark: "I am inclined to think that at about 90° Fahr. the Cagniard de la Tour state comes on with carbonic acid." Since Faraday wrote these words Dr. Andrews, in a series of classical experiments, introduced the word "critical temperature or point," at which compression of a gas ceases to produce its liquefaction, and has moreover established experimentally the critical temperature of carbonic acid gas to be 31° C., or only 2° different from the conjecture of Faraday.

Physical Conditions Dependent upon Temperature.

Deg. F.	Deg. C.		Atmos. pressure.
+698	+370	Critical point of water.....	=195·5
+311	+155·4	" " sulph. anhyd.	78·9
+285	+141	" " chlorine.....	83·9
+266	+130	" " ammonia.....	115
+212	+100·2	" " sulphtd. hydr.	92
+ 98	+ 37	" " acetylene.....	68
+ 95	+ 35·4	" " nitrous oxide.	75
+ 89	+ 31·9	" " carbonic acid.	77
+ 50	+ 10·1	" " ethylene.....	51
+ 32	— 0	Nitrous oxide boils at 32 at. pres.	Faraday.
+ 32	— 0	Carbonic acid boils at 36 at. pres.	"
+ 14	— 10	Sulphurous anhydride boils....	"
+ 15	— 10·5	" " " boils....	Bunsen.
— 10	— 23	Methyl chloride boils.....	Regnault.
— 10	— 23	Carbonic acid boils at 19·38 atmos. pressure.....	Faraday.
— 20	— 29	Sulphurous anhydride boils in current dry air.....	Pictet.
— 20	— 29	Carbonic oxide and oxygen, air and nitrogen, compressed to 300 atmos. in glass tubes and suddenly expanded, show liquefaction.....	Cailletet.
— 26	— 32	Alcohol containing 52 per cent. water freezes.....	Pictet.
— 29	— 33·6	Chlorine boils	Regnault.
— 29	— 33·7	Ammonia boils.....	Bunsen.
— 31	— 35	Commercial paraffin oil (sp. gr. 0·810) freezes.....	Coleman.
— 40	— 40	Nitrous oxide boils at 8·71 atmos. pressure.....	Faraday.
— 40	— 40	Carbonic acid boils at 11 atmos. pressure.....	Faraday.
— 40	— 40	Ethylene boils at 13·5 atmos. pressure.....	"
— 53	— 47	Freezing point of Hollands gin and French brandy.....	Coleman.
— 60	— 51	Nitrous oxide boils at 5 atmos. pressure	Faraday.
— 60	— 51	Carbolic acid boils at 6·75 atmos. pressure.....	"
— 60	— 51	Ethylene boils at 9 atmos. pres.	"
— 62	— 53	American petroleum (sp. gr. 0.790) freezes.....	Coleman.
— 62	— 53	Freezing point of extra strong whisky and rum.....	"
— 62	— 52	Alcohol containing 40 per cent. water freezes.....	"
— 80	— 61·8	Sulphydric acid boils.....	Regnault.
— 80	— 62	Nitrous oxide boils at 3 atmos. pressure.....	Faraday.
— 80	— 62	Carbonic acid boils at 3·75 atmos. pressure.....	"
— 80	— 62	Ethylene boils at 6·5 atmos. pressure.....	"
— 99	— 73	Critical point of marsh gas, pressure 56 atmos.....	Wroblewski.
—103	— 75	Liquefied ammonia freezes.	
—103	— 75	Alcohol containing 20 per cent. water freezes.....	Coleman.
—108	— 78	Carbonic acid boils.....	Faraday and Regnault.
—112	— 80	Solid sulphurous anhydride melts.....	Mitchell.
—123	— 86	Nitrous oxide boils.....	Faraday.
—123	— 86	Marsh gas boils at 40 atmos. pressure.....	Wroblewski.
—128	— 87·9	Liquid nitrous oxide boils.....	Regnault.
—144	— 98	Marsh gas boils at 25 atmos. pressure.....	Wroblewski.
—152	—102	Amyl alcohol an oily liquid.	Olzewski.
—152	—102	Silicon fluoride a white mass...	"
—152	—102	Arseniureted hydrogen liquid.	"
—152	—102	Hydrochloric acid boils.....	"
—152	—102	Chlorine orange crystals.....	"
—152	—102	Ethylene boils.....	Wroblewski.
—154	—103	" "	Olzewski.
—166	—110	Solid carbonic acid and ether in vacuo.....	Faraday.
—171	—113	Critical point of oxygen, pressure 50 atmos...	Wroblewski.
—171	—113	Marsh gas boils at 16 atmos. pressure.....	"
—175	—115	Solid carbonic acid in vacuo, 25 mm. pressure.....	Dewar.
—175	—115	Hydrochloric acid gas solid....	Olzewski.
—177	—116	Carbon disulphide solid.	
—180	—118	Arseniureted hydrogen white crystals.....	Olzewski.
—193	—125	Nitrous oxide boils in vacuo...	Dewar.
—200	—129	Ether solidifies.....	Olzewski.
—202	—130	Absolute alcohol solid.	
—209	—134	Amyl alcohol solid.....	Olzewski.
—218	—139	Ethylene boils in vacuo.....	"
—219	—139·5	Critical point of carbonic oxide, press. 35·5 atmos.....	Olzewski.
—220	—140	Critical point of air, pressure 39·0 atmos.....	"
—220	—140	*Calculated* temp. of carbonic acid snow in vacuo (?)..... ..	Pictet.
—220	—140	Hydrogen compressed to 650 atmos. and pressure released produces momentary liquefaction and solidification.....	Pictet.
—220	—140	Oxygen compressed to 320 atm. and pressure released produces momentary liquefaction.	Pictet.
—231	—146	Critical point of nitrogen, 35 atmos. pressure.....	Olzewski.
—238	—150	Ethylene boils in vacuo.....	"
—238	—150	Carbonic oxide boils at 20 atm. pressure	"
—242	—152	Atmospheric air boils at 20 atm. pressure	"
—247	—155	Marsh gas boils.....	Wroblewski.
—299	—184	Oxygen boils.....	"
—312	—191·4	Air boils.....	Olzewski.
—312	—191·2	Air boils.....	Wroblewski.
—315	—193	Carbonic oxide boils.....	"
—317	—194	Nitrogen boils.....	Olzewski.
—337	—205	Atmospheric air boils in vacuo.	"
—348	—211	Carbonic oxide solidifies "	"
—351	—213	Nitrogen boils in vacuo	"
?	?	Hydrogen at 100 to 200 atmos. liquefies to colorless drops (in glass tubes 0·2 mm. dia. surrounded by oxygen boiling in vacuo)...	Wroblewski and Olzewski.
—355	—215	Calculated boiling point of hydrogen.....	E. J. Mills.
—460	—273	Absolute zero.	

N.B.—The critical points above freezing point of water are quoted from Professor Dewar. See *Chemical News*, Jan. 16, 1885.

Now the critical point of oxygen gas has only been determined within the last year or two, Wroblewski making it —113° C., which Prof. Dewar has recently shown at the Royal Institution is attainable by the very same means as Faraday employed in his experiments on this gas, so that the liquefaction of oxygen has been delayed forty years by the simple accident of Faraday's compression pump not working so well with this gas as with other gases; and it was reserved for Faraday's successor, Professor Dewar, to exhibit the experiment for the first time to the members of the Royal Institution last year.

Within the last two or three years the critical temperature of almost all gases except that of hydrogen has been accurately determined, and it will be observed that in the case of seven well-known gases, viz., sulphurous acid, chlorine, ammonia, sulphureted hydrogen, nitrous oxide, and ethylene, compression at ordinary atmospheric temperature is sufficient to produce liquefaction; but in most cases the pressure required is very high, namely, from 50 to 100 atmospheres, or from 750 to 1,500 lb. per square inch.

M. Cailletet, together with M. Raoul Pictet, are generally credited with the discovery of the liquefaction of oxygen and hydrogen by experiments conducted independently of each other, but about the same date.

Cailletet's apparatus consists of a strong glass tube with the closed end pointing upward, into which, by hydraulic pressure, a confined volume of gas was compressed, the tube being sometimes surrounded with a bath of some substance colder than the atmosphere; but M. Cailletet frequently trusted to the effect of the sudden expansion of the previously compressed gas for producing cold, so that he had to employ enormously higher pressures than he would have required for condensing the gas, supposing his tubes had been surrounded with something lower in temperature than the critical temperature of the particular gas he was experimenting with. Thus, he employed pressures of 300 atmospheres for liquefying oxygen, whereas, with a proper temperature, 60 atmospheres have been found to suffice. Moreover, this apparatus only liquefies the gas as a mist, or at the best in the form of drops. M. Raoul Pictet certainly succeeded in 1877 in producing liquid oxygen in somewhat larger quantities, visible for a few seconds, issuing out of a pipe when the cock was suddenly opened; but, apparently being unaware of the critical temperature of oxygen, he employed quite as high pressures as Cailletet.

The recent rapid advance in our knowledge of these liquefied gases has been owing chiefly to the employment of liquid ethylene as a means of cooling compressed oxygen, nitrogen, hydrogen, and other gases. Ethylene is what the older chemists called oleflant gas, and its boiling point in the liquid state is —102° C., or —152° F.; *in vacuo* its boiling point is as low as —150°, or —238° F. A tube or vessel surrounded with liquid ethylene, boiling *in vacuo—i. e.*, by means of a vacuum pump—becomes so cold as to liquefy atmospheric air, oxygen, nitrogen, etc., at very moderate pressures, so that to produce liquid ethylene in quantity is half way toward the attainment of these results.

It has been already shown that the critical point of ethylene is above the freezing point of water, so that liquefying this gas is merely a question of compressing it into tubes surrounded by ice to, say, 750 lb. per square inch. For this purpose a pump has been introduced by Cailletet, and described in the *Annales de Chemie*, tome xxix., 1883, which is said to be efficient for compression to high pressures, and worked by hand labor at 30 to 37 revolutions per minute, will yield liquid nitrous oxide or ethylene, at the rate of 400 to 500 grms. per hour, equivalent, say, to the one-tenth part of a gallon.

As, however, any kind of pump working at such high pressure is difficult to manage and liable to mishaps, I venture to think there could be no better plan than pumping the gas by suitable pump into a coil of pipes externally cooled by a stream of cold air discharged from one of the machines devised by myself for technical purposes, and now used in various parts of the world for freezing animal carcasses. Such machines are generally made to deliver continuous streams of air cooled to 50° or 80° below zero F., at which temperature it will be seen by the table ethylene liquefies at the reasonable pressure of about 8 atmospheres, or 120 lb. per square inch, and nitrous oxide and carbonic acid at the reasonable pressure of about 4 atmospheres, or 60 lb. per square inch. In my recent experiments in conjunction with Prof. McKendrick upon the influence of cold upon vital phenomena, our cold air machine delivered air at —86° C., or —123° F., which is sufficient to liquefy carbonic acid gas and nitrous oxide without any pressure, and ethylene at the small pressure of 50 lb. per square inch.

Being, then, supplied with liquid carbonic acid, nitrous oxide, or ethylene in quantities, extremely low temperatures can be obtained, and it is by such means that the Russian observers Wroblewski and Olzewski have liquefied atmospheric air and other gases, such as nitrogen and carbonic oxide, in sufficient quantities to study their boiling points and other physical characteristics. As, however, boiling any liquefied gas *in vacuo* is troublesome, and involves vacuum pump as well as compression pumps, liquid marsh gas is a very convenient substance to use in liquefaction of atmospheric air and hydrogen, as its boiling point in the *atmosphere* is lower than the boiling point of ethylene *in vacuo*. Liquid marsh gas could be easily prepared by compressing it to 50 atmospheres in tubes surrounded by cold air at —80° C. discharged from a cold air machine. Its boiling point in the atmosphere is —155° C., and *in vacuo* is so low that it would probably liquefy oxygen, and without any compression.

If a cold air machine could be constructed for delivering the air cooled to below the critical temperature of oxygen—and I think this is not impossible—then this gas could be liquefied by compressing it to the extent of 100 atmospheres in a coil surrounded by such cold air. Such a process would be simple in principle, but the mechanical details more difficult than the stage method I have already described.

I must now direct attention to the general results of research as tabulated in the form prepared for this address, and first I must point out the extreme difficulty of measuring temperatures below which not only mercury becomes solid, but also such substances as alcohol, bisulphide of carbon, and ether, and which makes it necessary to use a perfect gas thermometer, or at any rate a gas so far removed from its point of liquefaction that it behaves as a perfect gas in expanding or contracting in the ratio of the absolute temperature.

Now, it appears from the researches of the Russian chemists Wroblewski and Olzewski that, at the temperature at which air becomes liquid, hydrogen gas is unliquefied at 100 atmospheres, and therefore it is reliable for measuring down to that point, which is only about 70 above absolute zero, and it is understood that one of the Russian chemists has employed such a thermometer, while the other observer has used a thermopile, the published results corresponding fairly well; but it must not be hastily concluded that such electric measurements are as reliable as the employment of a good gas thermometer.

You have on the table a form of gas thermometer devised by myself, and which has been recently described to the Society in detail, also to the Society of Chemical Industry.

When liquefied gases are exposed freely to the atmosphere they evaporate at an enormous rate, which, however, is speedily checked and almost stopped by the large quantity of heat carried off by the rising vapor, and necessary to its assumption of the gaseous state, and which, robbing heat from the rest of the liquid, keeps down its temperature. Otherwise, there would be no dealing with these liquids when exposed

*Address of the President of the Chemical Section, Philosophical Society of Glasgow, March 18, 1885.

to the air. It is otherwise, however, if the liquefied gases are corked or sealed up, as occurred with the samples of CO_2 and NO_2 shown you to-night. So that, in the case of liquefied air or oxygen, vessels able to withstand 200 atmos. pressure, or 3,000 to the square inch, are necessary for storage, and with these gases the bottles containing them would require to be cooled to below the critical point, or the contents would be in the Cagniard de la Tour state.

From an engineering point of view, however, the storage of such liquids is quite easy, especially in bundles of iron pipes connected with a common outlet. Thus, the air of a large lecture room, say 20,000 cubic feet capacity, when liquefied, would measure 150 or 200 gallons, and could be stored in 150 pipes of 10 feet long, 2 inches diameter, and ⅛ inch thickness of metal; indeed, by the formula commonly used by engineers, the thickness of an iron boiler of 12 inches diameter to contain the whole 200 gallons would require to be about 3 inches.

The critical point of hydrogen gas has not been determined, but one of our members, Prof. E. J. Mills, of the Andersonian University, calculates that from theoretical considerations it will be about —213°.

Pictet maintains that he has solidified it in the form of metallic particles, but this has not been confirmed, other observers having condensed it as a colorless liquid. It appears, therefore, that before long every known substance on the face of the earth will be capable of being solidified in the laboratory of the chemist by the mere abstraction of heat; and one cannot help being struck, in looking over the table I have already referred to, how, as temperature decreases, solidity gradually comes over the most active chemical agents, rendering them for all practical purposes as inert as so many pieces of stone.

Indeed, this tendency to inertness manifests itself before solidification occurs, for liquid carbonic acid, according to Gore, is unable to redden litmus, and is a comparatively inactive substance. We must not, however, conclude that all affinities will be dormant; for instance, may not oxygen and hydrogen, as we know them, be dissociated water, and may not the continued abstraction of heat from a mixture of these gases cause their union and the production of ice synthetically?

Against such a hypothesis, however, is the fact that liquefied atmospheric air has proved to be merely a mixture of nitrogen and oxygen, and not any form of oxide of nitrogen.

The facility with which alcohol freezes in all its forms is very interesting; and I may also mention that at about —86° C. the flesh of animals, such as mutton, becomes so exceedingly hard that it rings like porcelain when struck with an iron instrument, indeed crushes by the blow of a hammer into a fine powder, in which muscle, fat, and bone are intermingled; and what is still more singular, according to the experiments of myself and Prof. McKendrick, recently communicated to the Society, it appears that microbia alive in the flesh before the freezing operations can be detected still alive after thawing, even after exposure to —86° C., or —133° F., for one hundred hours; thus pointing out to potential animal life in the solid state capable of being brought into activity by heat and moisture, just as a dry pea shoots into activity by the moisture of the soil and the heat of the sun.

Passing now from the consideration of low temperatures, I have to direct your attention to certain phenomena which are invariably associated with high temperature, particularly the phenomena of artificial light. In these days of dynamos it appears, on the face of the subject, that light produced by electricity is essentially a mechanical operation; but such is not the case. *So long as coal or gas* is burned to drive the steam-engine which actuates the dynamos, the process in its origin is chemical, and it will not be otherwise until the electrician confines himself to getting energy from the fall of water or the motion of the tides or the wind.

As a rule, he will probably have to look to chemical action for the origin of his power, in which case a galvanic battery or a dynamo may be defined as a piece of apparatus by which the heat produced by a chemical operation, instead of being developed at the dynamo or in the battery, is developed a long way off, the process and the resultant being connected by a wire.

Although the production of artificial light is not altogether a question of quantity of heat, but rather of the incandescence of solid particles at a high temperature, still there is no question that it is more economical to burn a substance in the immediate vicinity where heat is required than to have the chemical action at a distance, which involves loss of energy in transit.

Lighting by electricity will always, however, have this great advantage, namely, that the apartments being lighted are not contaminated by the products of combustion, such as carbonic acid and sulphurous acid, which contaminate the air of apartments when gas is burnt.

The cost of electric lighting has been ably dealt with in a lecture delivered by Mr. Probert to the Society of Arts, September 12, 1884. The statements therein made have been assumed to be correct by such authorities as the editors of *Engineering*, and are to this effect, viz., that 100 incandescent lamps of ¾ ampere and 100 volt E.M.F. require 12¼ H.P., or 56¼ lb. coal burned per hour under a boiler. Assuming that the light burn five hours daily, and taking into account interest and working expenses, the cost amounts to 8*s.* per day for the 100 lamps.

Mr. Probert then calculates the cost per day of a galvanic battery for effecting the same object, which he makes out to be about 40*s.* per day, involving the use of—

	£	s.	d.
85 lb. zinc per day	0	13	3
71⅛ lb. sulphuric acid per day	0	5	11
Depolarizing chemicals	1	1	8
	2	0	10

Thus it will be seen that the cost of the electric current, by burning zinc in a battery instead of coal under a boiler, is five times as great.

Recently two Italians, Messrs. Bartoli and Papasogli, are said to have invented cells in which gas carbon or charcoal is oxidized by using a solution of sodium hypochlorite, and that the electromotive force of the cells varied from 0·4 to 0·5 of a Daniell cell, the oxidation products being mellic acid and other benzene carboxylic acids. The cost of the chemicals and the want of a ready market for the products of oxidation will, however, probably prevent such processes being commercially useful on the large scale.

It seems very singular to me that more attention has not been bestowed upon the utilization of iron as the substance to be burned in a battery, seeing that the oxidation of iron, according to the researches of Andrews, develops about three-fourths as much heat as the oxidation of zinc. The exact figures are these: when iron is used for precipitating a solution of sulphate of copper, 677 units as against 847 units developed when zinc is used.

IRON AS A BATTERY ELEMENT.

Iron has been frequently used as the electro-negative element of a battery, especially when in the passive state, by contact with concentrated nitric acid. Probably the objection to its use as an electro-positive element has arisen from earlier experimenters finding local action uncontrollable, which in the case of zinc was easily obviated by amalgamation. I have recently made some experiments in this direction; in point of fact constructing a sulphate of copper cell, in which the copper is used in contact with sulphate of copper, as is customary in Daniell's cell, but the zinc is replaced with iron used in contact with protosulphate of iron; and find that three of such cells connected in series decompose water, so that the electromotive force is probably what theory indicates, about two-thirds that of a Daniell cell; moreover, such a construction of battery gives what the chemist dearly loves—a chemical cycle easily worked, restoring the chemicals to their original state. The solution of sulphate of iron produced by the battery on evaporation and distillation yields sulphuric acid (or sulphurous acid) and peroxide of iron, the former ready to be combined again with the deposited copper, and the latter ready for the blast-furnace and reduction to metallic iron. I find a form of cell similar to the Sir Wm. Thomson or Medinger cell, with some practical alterations in detail, to suit best, and which, requiring no porous cells, can be made of any dimensions. A saturated solution of sulphate of copper contains one-fifth of its weight of the salt, and it floats upon a saturated solution of sulphate of iron, which contains only about one-third of its weight of the salt, so that if the sulphate of iron is drawn off as a saturated solution the copper plate requires to be at the top and the iron at the bottom of the cell.

If, however, saturated solution of sulphate of copper be put into a bell-jar, and metallic iron be placed in the upper part of the jar, the copper is replaced by iron, and we have a solution of sulphate of iron half-saturated floating upon a solution of sulphate of copper fully saturated. The line of demarkation between the two solutions remains quite distinct for weeks, and very little diffusion occurs; consequently a very manageable cell is made by a horizontal copper plate being put at the bottom of a cell containing a saturated solution of sulphate of copper, and one or more vertical iron plates being placed above in half-saturated solution of sulphate of iron. The solution of sulphate of iron is easily protected from the action of the atmosphere, and consequent decomposition, by means of a thin layer of mineral oil. If from time to time a solution of sulphate of copper is poured down a wide tube reaching to the copper plate, the iron solution being simultaneously drawn off from a higher level, a constant battery is constituted, which involves no cost in working beyond that incidental to the removal and recovery of the products, and which throws no product into the market the sale of which would be doubtful.

More plate surface, however, requires to be used with iron than with zinc, but iron is only one-fourth the price of zinc. I have found that three iron cells only give two-thirds of the electrolytic action given by two zinc cells, so that in practice probably the iron plates require to be double the size of the zinc plates for equal currents of electricity; but even then the arrangement should approximate in economy to the cost of lighting by the dynamo. It is obvious, also, that torrents of electricity could be evolved from the iron used in precipitating copper by the wet process of Henderson and others, if tanks be arranged in a similar way.

Before passing from the subject I may mention that I have obtained powerful currents by dipping pans of iron and copper into a solution of common salt mixed with chloride of lime.

Although gas-lighting has been with us a settled institution, it does not follow that the only competitor it will have to contend with is the electric light; for, notwithstanding the predictions to the contrary, oil-wells are not becoming exhausted, but, on the contrary, vast tracts of country—especially in the south of Russia—abound in inflammable liquids, apparently inexhaustible.

All of these liquids when burnt in lamps smoke terribly, the evil being got over by the employment of long glass chimneys, which, however, only effect the object when the oil to be burnt is light in specific gravity. The experiment which I show you this evening proves that all such oils can be successfully burnt without smoke by means of circular wicks of asbestos, around the outside and into the center of which a current of compressed air is made to flow upward.

It is easy to conceive that lamps on this principle can be constructed on any scale of magnitude, and that a town or community could be supplied with compressed air instead of gas, an arrangement which might suit Dr. B. W. Richardson in the future city of Utopia, though whether Sir F. Bramwell would be equally gratified I do not know, as he has recently told the public that gas-engines will in future supersede steam-engines.

It is a significant fact, however, that recently an act of Parliament has been obtained for supplying Birmingham with compressed air, for working small engines instead of steam.

Connected with the subject of high temperatures, I will briefly refer to the death of Sidney Gilchrist Thomas, who has passed away at the early age of thirty-five, worn out with the toil of superintending the vast developments of the inventions of himself and his cousin, P. C. Gilchrist. These two young chemists in six years have revolutionized the iron manufacture of two districts in England, and of France, Germany, Austria, Russia, and Belgium. The basic process invented by them is a pure product of the chemical laboratory, and has accomplished the abstraction of phosphorus from Middlesbrough and other irons, a problem which has for years baffled the most strenuous efforts of Lowthian Bell, Siemens, and Bessemer.

I hope the few facts brought forward will show the importance of a thorough knowledge of chemistry to the other branches of science and to many of the arts. We all know Faraday as an electrician and physicist, but he was originally a chemist, and remained Professor of Chemistry to the end of his life. We all know James Watt as a great engineer, but he was also an excellent chemist, and divides with Cavendish the honor of the discovery of the chemical composition of water.

The address was illustrated by numerous experiments, and awarded a vote of thanks, moved by Dr. Henry Muirhead and seconded by Prof. Sir W. Thomson, who complimented Mr. Coleman on the great interest of his paper and his researches. He thought that Mr. Coleman's hydrogen thermometer might be relied upon to register temperatures as low as those hitherto observed by the Russian chemists, but the notion of a perfect gas thermometer was not admissible in the face of the researches of Dr. Andrews on the continuity of matter. The absolute zero, indeed, is fixed from considerations independent of this, and might possibly be attained experimentally in future researches.

Sir W. Thomson also referred to the experiments on micro-organisms, and said it would be most interesting to see if Mr. Coleman's deduction—"that potential life can exist in a solid state"—is confirmed by experiments on vegetable seeds, with a view to ascertaining whether their vitality is destroyed by desiccation in a Sprengel vacuum or by long continued drying at moderate temperatures.

A committee is now being organized to carry out this inquiry, and it is understood that Mr. Coleman and Dr. McKendrick are continuing their experiments. —*Chem. News.*

A RELAY FOR TELEPHONE CALLS.

IN the telephone offices of Germany communications are made in the following way: The subscriber, X, calls

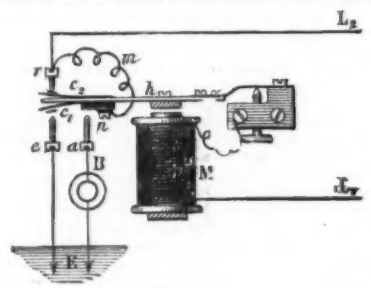


FIG. 1.

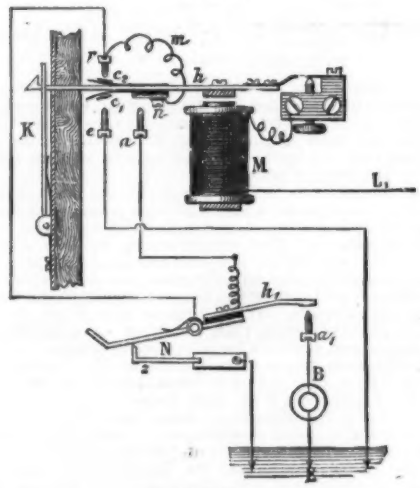


FIG. 2.

RELAY FOR TELEPHONE CALLS.

the office, and asks to be connected with Y. If the latter is free, the office makes the connection, and it is X who calls Y, and who, when the conversation is ended, gives the signal to the office. This method has the inconvenience of necessitating, for a few subscribers only, very distant from the central office, a large number of piles at the houses of all the other subscribers, in order that the call may be heard in case one of these latter desired to enter into communication with a subscriber of the first group.

Mr. W. Oesterreich proposes, in the January number of the *Elektrotechnische Zeitschrift*, to remedy this inconvenience by having recourse to a relay such as is shown in Fig. 1. Here M is an electro-magnet having a but slightly resistant winding. The current from the subscriber who is calling enters at L_1, traverses the electro, M, and enters, through *h*, *n*, *m*, *r*, and L_2, the house of the person called, where it is too weak to cause the call to operate. But, at the same time, the electro-magnet, M, has attracted its armature, and the spring, c_1, has pressed against the terminal, *e*, so that the circuit of the piles of the person calling is closed at the ground at the same time as the system of local piles, B, is sending its current into the line, L_2, through *a*, *n*, *m*, *r*, and L_2. The regulating of the apparatus must be performed with care. It is necessary, in fact, that the spring, *c*, shall come into contact with *e* before the contact between c_2 and *r* is interrupted; otherwise, the relay would operate as an automatic interrupter, and it is only when the contact, c_1, *e*, is established that (the intensity of the current increasing in the line, L_1, as a consequence of the diminution of the external resistance) the electro, M, energetically attracts its armature and closes the contact, *a n*. When once well regulated, the apparatus, it appears, operates very satisfactorily.

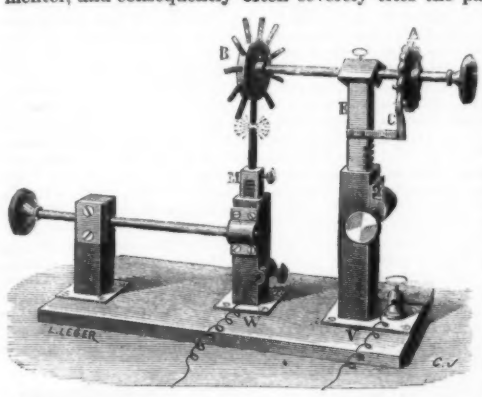
Fig. 2 represents a complete installation of the system

in a central office, with an annunciator, K, and connecting device, N. The travel of the current is clearly enough shown in the figure to render explanation superfluous.—*La Lumiere Electrique.*

HAND REGULATOR FOR THE ELECTRIC LIGHT EMPLOYED FOR THE PROJECTION OF SHADOWS.

IN the *Journal de Chimie Appliquee* (says *La Lumiere Electrique*), Dr. Walter contributes a communication relative to an apparatus by the help of which it is possible, without difficulty, to render various substances incandescent for the purposes of spectrum analysis.

It has been usual to employ the Duboscq lamp in such cases.* The introduction of the substances into the cavity at the extremity of the lower carbon is not an easy operation when the arc is formed; the dazzling effect of the light is very troublesome to the experimenter, and consequently often severely tries the patience of the audience. Dr. Walter has constructed the apparatus of which we give a figure, which acts solely as a hand regulator, so that the exhibition of the shadows does not practically occupy any time. The disk, B, of copper forms the chief part of the instrument; it is 50 mm. in diameter, and 15 mm. thick. It is provided at its circumference with a number of radial screwed holes, in which the carbon rods (about 8 mm. in diameter) are screwed in such a way that they project about 50 mm. Before being inserted in their places, the carbon rods are saturated in various metallic solutions, and then dried; one of the rods is left unprepared, so that it can be used to show the ordinary spectrum of carbon. The plane of the disk, B, makes a right angle with the plane of the mirror of the projection apparatus, and scarcely cuts off more of the light than a single carbon does. In order to keep B in its proper position, the axle of B carries a disk, A, the contour of which is wave-shaped. By turning the axle, the spring, C, drops into one or other of the depressions, and keeps the disk steady in the corresponding position. On the disk, A, the symbols of the elements are engraved in an order corresponding to the order in which the prepared carbon rods are arranged. The disk, A, is outside the projection apparatus, so that any required element can be brought in position without difficulty.



The opposite electrode is either of a disk similar to the disk, A, or a single carbon, as shown in the figure. The sliding uprights, M and E, have attached to their lower extremities the ends of spirals of copper wire, the other ends of the latter being attached to the base plates, W and V.

* For several years past an apparatus devised by M. Boudreaux, and of which the principle is analogous to that described by the writer, has been used in Paris.

RAILWAY ELECTRIC LIGHT PLANT.

MESSRS. LUCAS & AIRD, the contractors for the Suakim and Berber Railway, have decided to adopt electric lighting in order to encounter satisfactorily the obstacles as to climate, etc., which have been so much spoken of by our contemporaries and the public. By this means they intend, says *Engineering*, to construct this railway during night-time, when the temperature will be such as Europeans can withstand with tolerable ease, while during the heat of the day they can take their rest.

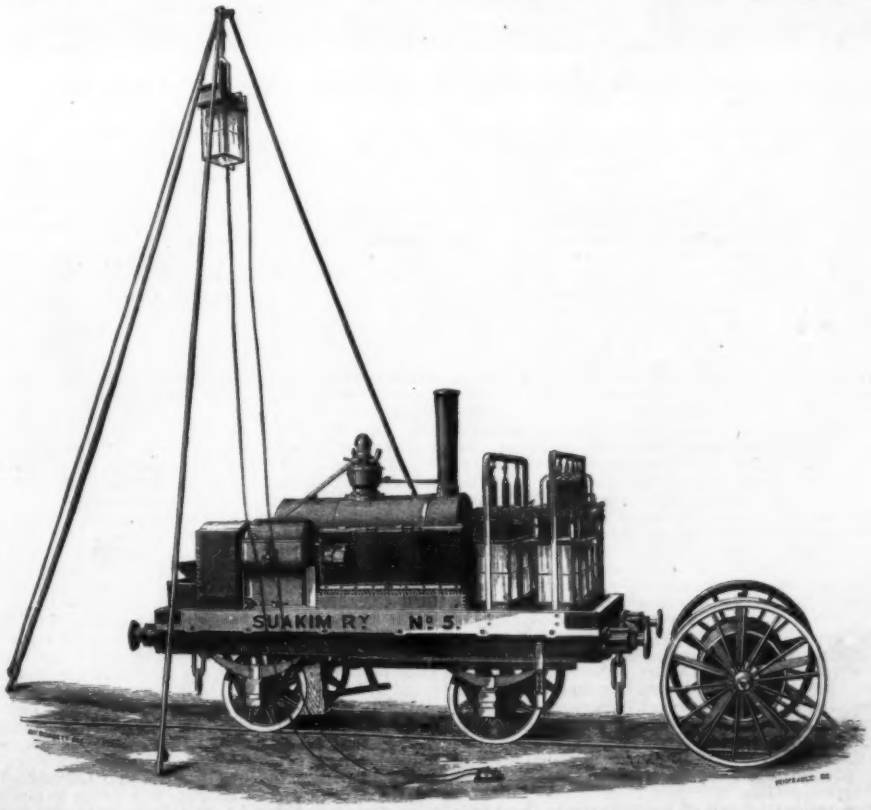
To carry out this arrangement Messrs. Kitson & Co., of Leeds, have already supplied two complete installations for electric lighting, and as will be observed from the illustration, the arrangement is very compact and well adapted to the requirements, considering the short space of time which they have had at their disposal for the manufacture of these two sets, although it may be mentioned that for some considerable time they have made this class of work one of their specialties.

The engine, boiler, and dynamo for each set, as well as the supports for the lamps when not in use, are all neatly fixed on a specially designed light railway truck. When in use the lamps will be hung from iron tripods 32 ft. in height, and placed at intervals of 30 yards along the line of the proposed railway.

The tripods are made of light iron tubing jointed at the top and made telescopic in the middle, so that they can be folded together, removed, and united wherever required with the least possible trouble. The insulated cable to convey the electric current to the lamps is coiled on reels, two being supplied with each installation. On these reels the cable can be run off or wound up as required. The lamps, which are of 2,000 candle-power each, can also be moved forward, one at a time, from one end to the other as the work of construction proceeds, a simple switch arrangement being provided for the cutting off of the current from any particular lamp without interference with any of the others. The dynamo machines are of the Brush type and are driven by Parsons' patent high-speed engines, of which a description was given on page 226 of our thirty-seventh volume.

The boilers are of the locomotive type, and are supplied by means of a feed pump with water from a tank fixed under the dynamo machine, which latter by this means is also kept cool during work. The carbons of the lamps are arranged to burn for a period of 16 hours.

Messrs. Kitson & Co. have two more complete sets to supply to a second order from Messrs. Lucas & Aird, the general details and the entire arrangement of the first set having been recognized and acknowledged to be well suited to the general requirements. Four sets can thus be kept in regular and constant use.



ELECTRIC LIGHT PLANT FOR THE SUAKIM-BERBER RAILWAY.

THE SOAP BUBBLE.

PROFESSOR A. W. RUCKER recently delivered a lecture at the Royal Institution, upon "Liquid Films—a Soap Bubble." Commencing with a reference to molecular theory that liquids are composed of a number of separate particles or molecules, the lecturer stated that the molecules on the surface of a liquid are in a less tightly packed state than those in the interior. This result he attributed to the molecules in the interior being completely surrounded by other molecules, while those on the surface are only partially encompassed by molecules of the same matter. In support of this theory Professor Rucker showed an experiment illustrating the different viscosity of a liquid at different depths. This was ascertained by the amount of attraction a magnet had upon a needle immersed at varying depths in the liquid. Some tabular results obtained by the lecturer with this method showed that the viscosity was about forty times greater at one-tenth of a millimeter below than upon the surface of a two per cent. solution of saponin in water.

Some objection has been raised to these results on the supposition that there is always a film of impurity upon the surface of a liquid, and that the action of the air might affect the experiments; but as similar results have been obtained by other methods, little importance is attached to these objections. Reverting, then, more especially to soap bubbles, which he mentioned incidentally are best obtained with a clay pipe previously soaked in the soap solution, Professor Rucker said that the film of a soap bubble consists of three parts, two superficial layers forming a skin and the liquid interior. The curvature of the bubble has a direct influence upon the amount of pressure exerted by the bubble upon the atmosphere inside it, and the lecturer has found that a greater pressure is exerted by a small bubble than by one of larger curvature. This fact the lecturer considered to be due to the diminution of the interior liquid in the film of the larger bubble and consequent diminution in pressure.

It can be illustrated by connecting a larger bubble with a small one, when, the pressure being equalized, the smaller bubble collapses while the large one increases in size. But it has also been determined that the composition of the film of the bubble remains the same regardless of size. Both the composition and degree of thickness of the film have been determined by means of electricity, but in conducting these experiments elaborate precautions have to be taken in order to ensure that the conditions remained unaltered in every case. It is necessary that the atmosphere in which the experiments are conducted should contain a constant amount of moisture, and also possess a constant temperature. Professor Rucker prefers his observations to be taken in an inclosed vessel flooded with the soap solution and surrounded with water. The apparatus used by the lecturer consists of two small cylindrical cups, between which a cylindrical bubble is blown. Into this bubble two gold needles are inserted a certain distance apart, and the thickness of the film is calculated from the resistance offered to an electric current passed between the needles.

In an experiment shown, different colors were projected upon a screen according to the varying thickness of the film of the bubble. The thinnest film that can be obtained gives a black ring. An extremely rapid change of thickness is observable at the boundary of black, the comparative thickness of the film giving the next color, green, being sixty-five times greater, although the missing colors have been distinguished with the aid of the microscope. While carrying out these experiments, the observation was made that if the electric current passed in the direction of the earth's gravity, it accelerated the collection of material at the bottom of the bubble and the consequent diminution of thickness in the film; but if the current were passed upward, the thinning of the film was not only retarded, but the force exercised by the earth's gravity was reversed. As showing the delicacy of the results obtained by the electrical method, a film has been measured to within one millionth part of a millimeter; indeed, owing to doubts expressed as to the truth of this statement, an optical method has been devised which gives nearly the same results.

A ray of light is passed by means of a prism along a glass tube about 18 inches in length, containing fifty or sixty soap bubbles, and closed at each end with a glass plate. The bubbles are then broken, and the thickness of the films is obtained by calculation based upon the difference of refraction of light before and after the bubbles are broken. As it is highly necessary to break the bubbles within the tube with the minimum amount of disturbance to the apparatus, a steel needle is inserted in the glass tube, which, when attracted along the tube by a magnet, breaks the bubbles. As a mean of several experiments conducted both by the electrical and optical mode, it was found that the thickness of the thinnest or black film is eleven millionths of a millimeter.

SPONTANEOUS GENERATION.

THE ideas on this subject, and the experiments tried to ascertain their correctness, have hitherto been very crude and erroneous. It is very unscientific to suppose that, even if spontaneous generation was a part of the ordinary production of living matter, it could occur either from ordinary simple matter or under the conditions prescribed for its appearance by those who have investigated the subject of its existence. Protoplasm in its chemical composition is the most complex of the various kinds of matter; and these kinds of substance never originate from the simple elements, or even from the simpler compounds, but from materials which, while possessing a degree of complexity less than their own, are yet removed from the ordinary elementary and simplest forms of matter.

Where is the protoplasmic cell, however simple, that could derive its existence from either water or any other similar simple compound? Again, tests of the reality of spontaneous generation are not considered of value unless the liquid used be first rendered untenable to any germs that may have first existed in it. The very process, however, which destroys the organisms already in the liquid renders it unfit to sustain the vital properties of the protoplasmic cell. Where is the organism which can derive the means of growth or existence from a liquid which has been thoroughly boiled? But man is unable to meet the requirements necessary for the formation of even the complex organic compounds; he must be content to obtain them as they occur in nature. How, then, is he to fulfill the conditions necessary to the creation of the still more complex compound of protoplasm? The true method of investigation is to observe the manner in which nature forms protoplasm, like all other chemical compounds, from those which are simpler in their composition. What are the chief properties of protoplasm? They are undoubtedly those of growth, contractility, and reproduction. The first step in the inquiry into the question of the ability of protoplasm to originate without a preceding substance of its own nature is to consider the relation between it and the commoner forms of matter. It may easily be shown that it possesses properties entirely analogous to those of protoplasm. Suppose we divide a certain quantity of water into two equal portions; this process is strictly analogous to the division of the protoplasmic cell, by which two cells or, more exactly speaking, two quantities of protoplasm are produced, the cell structure not being a constant accompaniment of protoplasm. Let the two quantities of water unite with oxide of lime to form the hydrate; the process is analogous to growth, since

this is nothing but the combination of the tissues, or, in the case of the simpler forms of protoplasm, the combination of the cell with the materials necessary to its increase and preservation. Again, the property of contractility of protoplasm, which is simply a form of force due to chemical combination, is imitated by the force given out by all kinds of matter during chemical combination.

Having shown that the vital properties of protoplasm have their analogues in ordinary matter, without trying to prove that these analogous properties in both are the same, which could easily be done, let us see whether we may not observe in the various processes which occur in the laboratory of nature a transition form of matter—a kind which can strictly be said to belong to neither living nor ordinary matter, yet which possesses in a degree the properties of both. The form of matter which fulfills these conditions is that which ordinary food undergoes while in a process of digestion and assimilation. The albuminous ingredients of food while in the stomach have mingled with them the gastric juice, which is a vital fluid possessing all the properties of the gastric epithelium through which it has percolated, and of whose substance it must, therefore, partake. By this secretion the albumen of the food is dissolved, and the first step in the transition of it from ordinary matter to protoplasm is finished; it is now albuminose, and this neither more nor less than a transition form of protoplasm, for it is capable of combining with the epithelial cells of the gastric mucous membrane, which it does when it is passing through their substance; and when it enters into the blood it is soon transformed into the material which composes the various protoplasmic tissues. Here we see a substance which is not protoplasm, for it does not possess the properties by which protoplasm is distinguished from ordinary matter. Neither can it be classed with the common kind of substances, for it is so prepared that it is capable of entering into combination with the tissues, which are nothing more than the original protoplasmic cells of the ovum differentiated into the various forms of bodily tissue. Albuminose on entering the blood soon disappears; this is because it soon enters into combination with the tissues, after which it is no longer in a transitional state, but possesses all the properties of protoplasm. It may be said that it is decomposed in the various processes by which heat and muscular force are generated. It undoubtedly does become decomposed, but not until it has entered into combination with muscular fiber or some of the other tissues. Animal heat is in all likelihood nothing more than an accompaniment of the chemical changes which take place in the substance of the muscular fiber, by which the contractile force of muscle is generated. It is greatest during active exercise of the muscle, and in diseases characterized by rapid disintegration of muscular fiber, as the inflammations. Wherever protoplasm absorbs material for growth, there is a transitional form of protoplasm, and consequently spontaneous generation, since the material absorbed must become assimilated—fit for combination with the protoplasm—before such combination can be effected, and the remainder of the process completed. The matter assimilated must of necessity, being gradually transformed into protoplasm, have a stage in which it is intermediate in nature between simple and protoplasmic matter. In this form of spontaneous generation, however, there has been as the active agent in the process the protoplasm by which assimilation has been produced; and although transformed matter cannot be said to have originated from other protoplasmic matter, this has been concerned in its causation.

Whether protoplasm may ever come into being from simple matter alone can be determined by deductions drawn from facts which are known. We cannot, however, draw the dividing line between protoplasmic and ordinary matter. We have already seen that the properties of the two substances were nearly, if not quite, identical. If we observe a mass of putrefying albumen or albumen recently deprived of its living properties, at what stage of the putrefactive process can we say it is no longer protoplasm, or that it has become ordinary matter?

It is in the decomposition of the complex organic bodies that protoplasmic cells have their existence; and I believe it is capable of demonstration that they have their origin in such decomposition. No one, I believe, will dispute the fact that the putrefactive process is the most favorable condition for the existence of the various forms of cell life. Moreover, it is highly probable, if not a positive fact, that in a pure atmosphere or in pure water they can have no existence whatever.

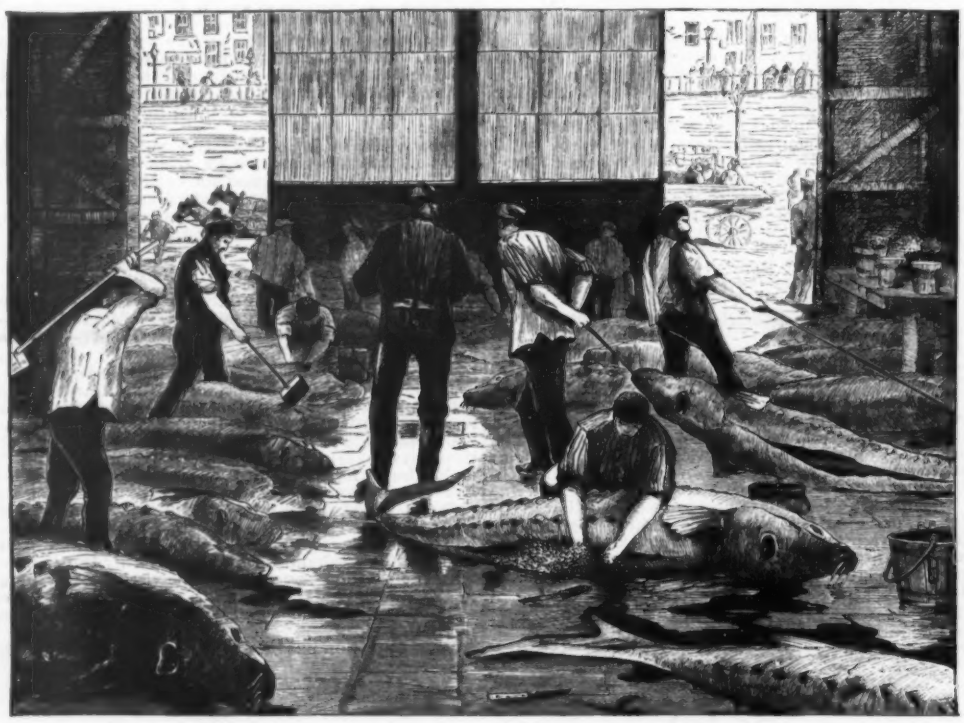
It has been shown that germs float in the air with dust, which is, however, invisible, excepting in sunlight. There can be no doubt that these germs owe their existence to decomposing matter, such as dead epithelial scales, muscular fibers, etc., floating in the air, in combination, it may be, with ordinary kinds of substance. The question now arises, Have these germs been propagated by other similar germs, or do they arise by development from the decomposing organic matter? It is capable of proof that not only may they be propagated by each other, but that the simplest forms of all life are spontaneously generated from the putrefying mass in which they have their origin. It is a law of progression that matter proceeds from the simple to the complex. The simple elements combine and form compounds; these compounds unite and form more complex substances, and these again, uniting with protoplasmic vegetable or animal substances, become developed into living matter. Protoplasmic progression is the same; whenever one protoplasmic cell unites with another, a third cell is formed possessing new properties; being composed of two cells, it must possess the properties of both, and thus a new species is produced, just as the union of two kinds of simple matter produces a new compound. Not only is every combination of one or more protoplasmic cells an improvement on those which have formed it, possessing, as it does, the properties of both, but the organism or individual is in general superior to its parents, for it possesses not only the characteristics of both parents, which have enabled them to successfully contend with the difficulties of life, but it has also the favorable circumstances which its parents have been enabled to gain for it. Thus development always proceeds from the simple to the complex, from the lower to the higher, both in the metamorphoses of living and inanimate matter. The simpler forms of protoplasm offer no exception to this law of progression; they proceed from protoplasmic cells still more simple than themselves, which, in their turn, have originated from still more simple cells; the ultimate beginning having been in the transition form that decaying protoplasm must undergo in its decomposition into inanimate compounds. If this were not the case, then we must conclude that all the various kinds of living matter have proceeded in their natural order of progression from matter of the same kind, endowed with the same properties, but which differs entirely from all its kindred species of protoplasm in never having progressed from a form of matter still lower than itself. This simple cell must, like all the others, have originated from pre-existing protoplasm, but, unlike all the others, it cannot possess the properties of all the protoplasm out of which it is formed; but some of these properties have passed out of existence—been destroyed in order that the product may not differ from the matter which has produced it. It is easy to see that this view is absurd. Acquired properties, unless abnormal, are never lost or destroyed. No form of protoplasm has ever yet been discovered but that there may be found a still lower form, and in its production it is never stationary.

It has been proved that all animals and all species have had their origin in lower forms of animal life, but even those who have established the theory of evolution have contented themselves with the idea that spontaneous generation has taken place only in the far-off ages of the past, and they have thrown around this apparently mysterious process the misty clouds of darkness which envelop the dim horizon of the infinite past, and which seem to be impervious to the sight of reason. What reason have we to suppose that conditions for the evolution of protoplasm have ever existed more favorable than those which now exist? It is a universal law of all vital matter that whatever will enable it to exist and to grow will also allow of its propagation; and, since the conditions now exist for the preservation and growth of protoplasm, it is plain that there exists for it also the conditions necessary for its spontaneous generation. This takes place in the following manner: When masses of protoplasm die, the process of death, like all those of nature, is a gradual one; hence, there must be a transition stage when the form of the original protoplasmic structure is partially or wholly lost, but in which some of the vital properties are still retained. Moreover, the putrefactive process is not uniform throughout the whole mass, but vitality may linger in some parts when it is wholly destroyed in others. In this transition stage the same chemical compounds which have by their combination formed the protoplasm of the decaying mass when liberated, retaining, though it may be in a less degree, their former powers of combination, having their former affinities, they must necessarily form new combinations; and as such combinations have formerly resulted in the production of living matter, so now protoplasm is also a result of the union, and a new form of living matter is formed, though much simpler in its nature than that from which it has sprung, just as the decomposition of all complex bodies gives rise to simpler ones in its decomposition, though these may themselves be of complex constitution. The evolution of this simplest form of protoplasm is further aided by the presence of parts of the protoplasmic mass which have not undergone decomposition. Portions of living matter in close contact with each other have a vitality in common with each other; it is conveyed from one cell to another just as heat is conveyed. It is because of this capacity of the vital properties to pass from part to part that tissues in which they are lowered by an injury have the means of recovery, and it is due to the same cause that the tissues adjacent to a diseased part, in which there is depressed vital action are always, to a certain degree, in the same condition. In the decaying mass those portions which retain their living properties impart of them to the simple forms of protoplasm which arise in this way, promoting their powers of growth or absorption and reproduction.

That the ordinary forms of matter may in their progression from simple to complex bodies arrive at such a degree of complexity as to be capable of forming living matter cannot be doubted, for otherwise there must be a break in the progression of matter from the simple to the complex—a stage of progression in which the complex compounds cease to have the ordinary combining powers of matter, a thing which needs only to be mentioned to be proved false. Just as compounds unite with each other and continually progress toward higher combinations, so cells of protoplasm, or among the simpler forms masses of protoplasm, uniting with each other, by their combination of properties produce higher organisms, and this progression continuing, there is at last developed and differentiated all the various tissues of the higher animals. The properties of the compounds of elements partake of the nature of those of the ingredients, and this development and improvement of properties continually progresses in proportion with the progression in the complexity of structure until are evolved the numerous and important vital properties of animal tissues upon which function is built. Development begins with the separation of a mass of elementary matter into its molecules, which are analogous to the cells of protoplasm. These molecules unite with elementary molecules of another kind, and thus a new body is produced having the properties of both its ingredients. Compounds again unite with each other, forming more complex ones with new properties, and this progression continues until is formed the simplest form of vegetable protoplasm. This separating into cells which unite with other cells is but a continuation of the progression, which is kept up until the highest forms of life are brought into existence. This progression of simple matter to the more complex forms is brought about by the natural forces which, by a continual agitation of the earth and atmosphere, enable the various kinds of matter to come in contact. These forces are gavitation, heat, electricity, winds, tides, and the motions of the earth in its orbit. There is not the wide separation between vital and inanimate matter usually supposed to exist. Both possess similar properties. The separation of matter into its molecules, and their combination with other molecules to form new matter, is similar to the protoplasmic function of reproduction; the attraction of surfaces is similar to the process of absorption in protoplasm, and in both movement is the result of chemical combination. This shows us how intimate is the connection between the two kinds of matter, and how easy the transition from simple to protoplasmic matter.

F. R. Hays, M.D.

Gansevoort, Saratoga Co., N. Y.



THE STURGEON SLAUGHTER HOUSE NEAR HAMBURG.

STURGEON SLAUGHTER HOUSE AT ST. PAULI, NEAR HAMBURG.

Many thousands of sturgeons, the largest river fish known, which furnish us with caviare, swim up the Rhine, the Weser, and the Elbe every spring. They pass up the Rhine to Mainz, in the Weser they are found near Hameln, and in the Elbe they go as far as Magdeburg. The greatest number of these fish is caught near Hamburg, where they are slaughtered in large quantities, and the caviare prepared.

The average weight of the sturgeon in these North Sea rivers is several hundred pounds, and the tender meat is very palatable, both when fresh and when smoked. In preparing the caviare the slimy matter is removed from the roe, which is then salted. The fishermen arrive at the sturgeon slaughter house in St. Pauli dragging the live fish after them. The fish are then killed by delivering several blows on their heads with a heavy mallet, the roe is removed and immediately prepared as caviare, the air bladder is cleaned and dried to be used in the manufacture of isinglass, and the body is cut up in the requisite pieces either for immediate use or for smoking.—*Illustrirte Zeitung.*

There is a salt lake in Hidalgo County, Texas, which is one mile in length, five miles in circumference, and from three to four feet deep. Its bed consists of crystals of pure salt.

A ROYAL DUEL.

TWO foresters who, in the month of December last, were passing through the rocky defile of Strathglass, in the Scottish Highlands, saw a remarkable incident, namely, a combat between an eagle and a stag. A herd of red deer were feeding in the hollow, led by a splendidly antlered stag. Overhead a golden eagle was hovering. Suddenly he swooped down upon the neck of the hart, beating the animal's head with his powerful wings, and striving to tear out his eyes. The stag endeavored to defend himself with his horns, and succeeded in tumbling his assailant violently into the heather, screaming and with torn plumage. But the bird speedily recovered, and again swooped down, this time on the haunches of his victim, and therefore out of the reach of his horns. His talons were buried in the stag's coat, while his beak tore at the bleeding flesh. It looked as if the bird would actually conquer, when the stag tried a new stratagem. He flung himself over in a complete somersault, so as to fall upon the eagle, positively rolling himself down the heather slope. Bruised and battered, the eagle lost his grip, and fell once more with tumbled feathers to the earth, while the stag set off at full gallop and sought the friendly shelter of a pine wood. He was not a whit too soon, for the eagle attempted to renew the attack. Finally, the hart, thoroughly beaten and dismayed, disappeared in the dark shadows of the wood, while the eagle, somewhat ruffled from the conflict, was last seen soaring away beyond the crags of Corrie Mor.—We condense the foregoing details from an account which appeared in the *Daily Telegraph.—London Graphic.*

A ROYAL DUEL.—DRAWN BY C. BURTON BARBER.

THE UNITED STATES AS IT WAS IN 1780; AS IT IS IN 1880; AND WHAT IT WILL BE IN 1980.

E. A. HICKMAN.

THERE is no problem likely to be presented to the statesmanship of our country in the next century that requires as much deep analyzing wisdom as the one

that demands homes and employment for the young men and women who are forming so vast a proportion of our population. To see this subject as it advances and increases in importance and magnitude we must look into the past and present, and from them anticipate the future.

I will give the population of the United States in 1780, and at the various decades since, with the per cent. of increase in each period of ten years:

	Population.	Gain, Per Cent.
1780	3,070,000	
1790	3,930,000	28
1800	5,308,000	35
1810	7,240,000	33·4
1820	9,659,000	33·2
1830	12,866,000	32·6
1840	17,069,000	35·8
1850	23,192,000	35·6
1860	31,443,000	24
1870	38,978,000	34·3
1880	50,156,000	30

In the century past the population has increased at an average of 33 per cent. compounded every decade. In that century, too, that population had hardships and impediments to surmount that may not impede progress or delay the increase of the next. In that century the active and inventive mind of the American mechanics and scientists has invented, and constructed, and patented 312,000 improvements on the old order of things, that the burdens and labors of life may be less oppressive; and of these all shops, farms, offices, stores, mills, boats, and railroads bear valuable fruits, and these classes of our citizenship have removed many hardships and privations; and those common to the beginning of the period mentioned are unknown to those who live in the later years.

In the beginning of that period, and from that on till now, the United States Government has had a vast domain of public lands for all who wanted farms; and liberal provisions were granted to every one who chose to locate on vacant land. Thus from any overcrowded locality the excess simply flowed into this vast territory of unimproved land, and in a few years, where there had been apparently a barren waste, there sprang up States with all the necessary functions of like governments a hundred years older.

To-day the area of the United States is, 3,110,061 square miles, exclusive of the Indian Territory	70,000
And of Alaska	720,000

This first area will equal a square whose sides are 1,764 miles long. This extensive expanse has been nearly all taken up by private individuals, and but little more is left for the pioneer.

What is now before the statesmen of our country for their prime consideration? It is this: How shall the vast increase of our next century (if it be in proportion to the last in per cent.) be supplied with homes and honest employment? These are necessary to the individual and the family; to hold them up in self-respect, and keep them on an elevated plane of citizenship where childhood and youth can be reared into maturity, pure, noble, and grand, as God wanted *man* to be; then with the *will* to labor, and the *place* to labor, he can go on in obedience to the divine command and live, and grow in mind and morals, and perfect himself. How much space *per capita* will the ending of the next century demand?

The 3,070,000 population of 1780 has grown in one hundred years to 50,156,000, and has extended from the confines of the thirteen Atlantic States, containing an area of 800,000 square miles, to one of 3,110,061 miles, and embracing thirty-eight States and seven Territories, all politically organized to furnish their citizens with the benefits of civil government and such guarantees as will enable families to rear their children with judicious efforts to honorable and respectable man and woman hood. Then if the 3,070,000 population of 1780 make an increase to 50,156,000 in a century, that last number in the next century will reach at the same ratio of increase 852,000,000 of people.

What provisions must be made for this enormous population? It must be supplied with honest, respectable labor to keep it above the ruinous sinks of vice, and to supply food, raiment, and house-room. How can that labor be applied to supply these necessaries?

In the various manufacturing departments now in operation, by the use of the improved machinery before alluded to an over-supply is now on the market, and dealers say there is but little profit in their trade. The farmer complains that his productions do not pay interest on his investment and for his labor.

The mechanic says his labor during the summer and fall months does not supply him with funds to sustain his wife and children during the idle days of winter, and the day laborer often suffers for the necessaries of life when summer and fall work has passed. If that be the condition of our population of to-day, what must it be a hundred years hence?

American citizenship of the nineteenth century is unlike the social condition of any former populace known to history. In other periods that have gone, there was an alliance demanded by the land-owner, and granted by the plebeian, who felt his inferiority because he was not an owner of land, and subject to the will of him who was.

A widely different state of things exists here; in the hundred years past, American thought, American character, American freedom, all have been cultivated into a unity, and become an object which so many of the rising generation are seeking to attain.

It is this freedom, this effort to rise, this persistent and logical thought of the young and laboring classes, that have given our government some of its wisest and best men. Our great systems of internal improvements have been built by the capital made by the energies of the country-raised boyhood, and some of the finest works of civil engineering are from the same class, and inventions that have revolutionized the commerce and civilization of the world have grown out of the same class of mind. Nothing so loudly proclaims the value of boyhood effort as the successes that have rewarded many citizens in every community.

But these vast demands for skill, and energy, and capital are ceasing. The railroads have been built; the streams have been bridged, the saw-mills have been constructed and worked up the forests into lumber; the flouring-mills are more than able to grind up the wheat production. The towns and cities have an oversupply of dealers in all branches of trade. The farmers are all supplied with buildings, and that most profitable and useful class of works known as agricultural machinery has supplied all previous necessities, and there is enough left to furnish the future demand for five years. Where now, with all demands supplied and enterprises comparatively finished, must the young men and women look for such work as will supply the wants of life and give such vitalizing influences to the germs of true greatness as will elevate them above the degrading effects of idleness?

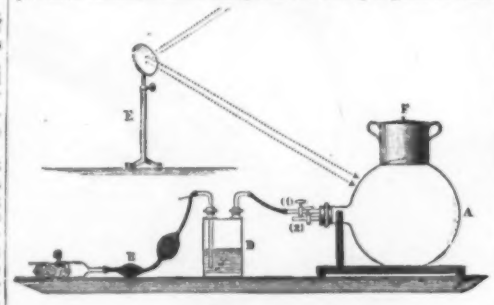
This freedom of American thought has in so short a time worked such wonderful results, and created such vast supplies, that it has to stop and ask, "What must I do next?" Cannot some man of broad, perceptive thoughts rise and answer the inquiry before the problem becomes entangled with other issues?

Independence, Mo., February 25, 1885.

—*Kansas City Review.*

A CLOUD GLOW APPARATUS.

By the kindness of Prof. J. Kiessling, of Hamburg, we illustrate a simple and easily arranged piece of apparatus which he has designed for the purpose of exhibiting on an experimental scale some of the many color phenomena which are produced when direct sunlight or electric light penetrates a moist or a dry cloud. In particular the apparatus can be used to produce on an artificially excited mist the same kinds of intense colorations which were visible in such extraordinary brilliancy in the winter 1883-84 during the hours of twilight at almost every place the whole world over.



The following pieces compose the apparatus:

1. A glass globe, A, Fig. 1, holding about 20 liters, fixed in a wooden support, and closed by a rubber stopper bored with two holes. Through these holes enter two tubes of glass (1) and (2), with taps ground in.

2. An air filter, C, consisting of a glass tube 30 centimeters long, filled with cotton wool.

3. An India rubber pump, B, for producing spray or mist. This is simply part of a common spray apparatus, and is set so that it draws air from the air filter and delivers it into the globe. By this means a pressure of one-sixth to one-fifth of an atmosphere is readily obtained. Suppose 15 or 20 grammes of water to have been introduced into the globe and such a pressure to have been produced, and then after about 10 to 15 seconds the other tap (2) to be suddenly opened, or removed quite out of the tube, the release of pressure will result in a sudden lowering of the temperature, and the production of a tolerably homogeneous mist, the density of which will depend on the quantity of aqueous vapor present.

4. A simple heliostat, E, consisting of a mirror capable of being turned either in altitude or azimuth on an iron stand, and also of being clamped at any desired height.

5. A Woulff's wash bottle, D. This can be filled with hot water so as to yield a supersaturated atmosphere; or, by the addition of ammonia or of hydrochloric acid, may furnish vapors of these materials for experiment in the globe.

6. A cylindrical tinware vessel, F, with a spherical bottom, to be set upon the glass globe, to heat or cool it as may be desired.

The following experiments may be made with this apparatus:

1. *The Ordinary Lunar Halo.*—First cover the surface of the mirror with a card disk having a central circular opening two centimeters in diameter, covered with tissue paper. In direct sunlight observe the bright surface of this circle of tissue paper (which serves as an artificial moon) through the mist that is produced in the globe by letting in a stream of moist vapor from a flask of hot water for a few seconds. The halo is yellowish with a red brown edge.

2. *Blue Sun.*—Pour into the globe a little hydrochloric acid, and blow in air through the wash bottle, having filled the latter first with liquid ammonia. A dust cloud of fine particles of sal-ammoniac is thereby produced. A ray of direct sunlight viewed through this is curiously colored, appearing at the first moment red, and then changing to bluish violet and to full blue.

3. *Artificial Cloud Glow.*—For producing the intense diffraction colors of the cloud glow, it is necessary to procure a cloud consisting of small particles all about the same magnitude. This is best attained if the air before entering the globe is first led through hot water. If the conditions are favorable, the colors are sufficiently intense as to permit of their being received on a white screen one meter distant. The colors change rapidly in a regular gradation of order, each color appearing first at the center of the field, and moving outward.

Several additional phenomena are to be observed with this apparatus, and its inventor has devised an ingenious proof of the once disputed point that the particles of mist are spherules, not vesicles. This he does by showing that certain diffraction phenomena which depend on the size of the particles, remain unchanged during a certain change of external pressure, which, if the particles were bubbles or vesicles, would at once cause them to expand.—*Nature.*

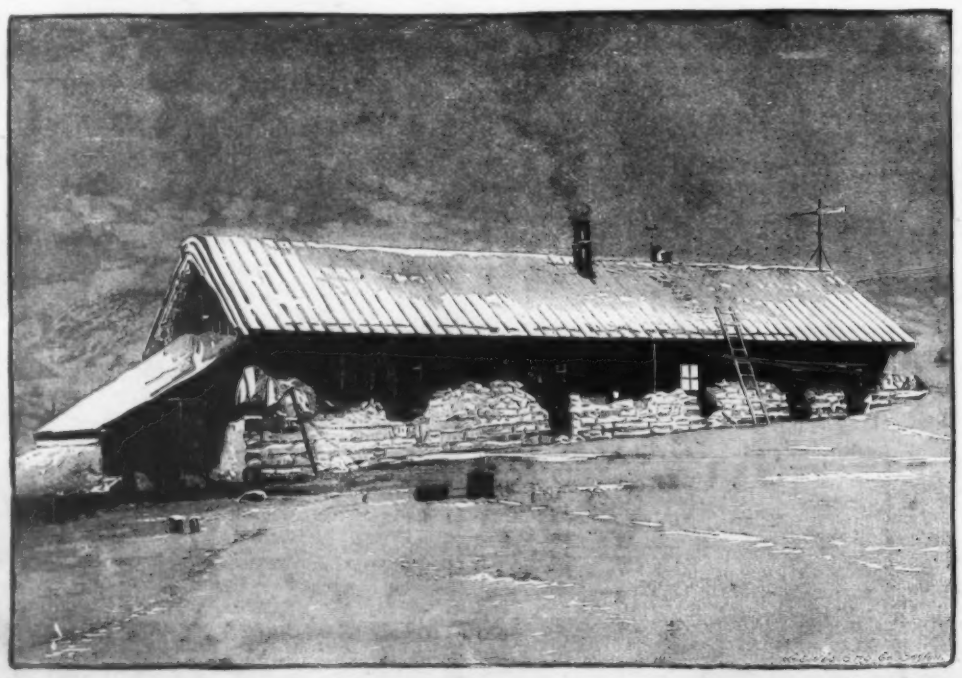
[SCIENCE.]

THE SCIENTIFIC RESULTS OF THE LADY FRANKLIN BAY EXPEDITION.*

THE general interest in the scientific work of most polar expeditions has been seriously affected by the long delay which necessarily occurs in the publication of the records and results. With the permission and concurrence of Gen. W. B. Hazen, chief signal officer, I take pleasure in giving, as far as I can at present, a brief summary of some of the scientific results of the Lady Franklin Bay expedition.

Hourly magnetic declination observations for thirty-two days on which they were made previous to July 1, 1882, were reduced at Fort Conger. The mean declination thus obtained was 100° 12′ west, being 1° 32′ less than the result deduced from the observations of the English expedition of 1875-76. The maximum easterly deflection occurred at 2 A. M., local time (7 A. M., Gottingen mean time), and the maximum westerly deflection at 12 M. A primary maximum at 4 P. M. most probably was due to disturbances. These deflections are from one to two hours later than those obtained from the observations of Lieuts. Archer and Fulford, R.N., in 1875-76; but it is possible that the observations for the complete year, which are now in the hands of Assistant Charles Schott of the U. S. coast and geodetic survey for reduction, may give other results. The hours, however, agree with those determined for Van Rensselaer harbor by Mr. Schott, in the discussion of Kane's observations. The absolute range of the English observations was 8°; and the greatest daily change, 5° 9·4′. From 8:35 A. M. (Gottingen mean time),

* The accompanying picture represents Fort Conger as it was photographed by Sergeant George W. Rice, in March, 1882, the print from which it was taken being one of the few that were brought safely home by the Greely party. The high ground at the northwest of the station is seen at the left. The picture represents the principal building occupied. There were three other small structures, astronomical and magnetic observatories, and an instrument shelter, the wires seen at the right running to the astronomical observatory.



THE STATION OF THE GREELY PARTY AT LADY FRANKLIN BAY.

Nov. 16, 1883, to 10:30 P. M., Nov. 18, the absolute range as observed was 20° 28·2′—from 113° 19·8′ west to 92° 51·6′ west. These times and figures are given as of more than common interest in connection with the great magnetic storm of November, 1883. The changes at Conger were much greater, it will be observed, than at Godthaab, Greenland, where, Paulsen says, on Nov. 17, 1883, from 2 A. M. until noon, the declination had varied 4° 44′ to the east, and later about 5° to the west; so that the variations for the day reached 9.5°.

The following table of monthly means has been compiled from three years' observations, 1875–76 and 1881–83.

	Barometer to sea.	Temperature.	Rainfall, inches (two years only)
January	29·756	—38·3°	0·42
February	0·779	—40·1°	0·13
March	0·962	—28·3°	0·45
April	30·175	—13·6°	0·17
May	0·021	+14·1°	0·40
June	29·852	32·7°	0·18
July	0·725	47·1°	0·66
August	0·787	33·8°	0·38
September	0·749	15·8°	0·35
October	0·925	— 8·9°	0·24
November	0·971	—23·3°	0·20
December	0·830	—28·1°	0·30
Year	29·878	— 3·9°	3·88

The barometrical observations show atmospheric changes which I believe are common to the region within the Arctic circle, north of America at least. The marked maximum pressure in April gives way rapidly to the principal minimum in July; to be followed by a secondary maximum in November, and a less marked minimum in January or February.

The hourly barometric observations are of special interest as tending toward a final solution of the question whether or not the regular diurnal variation observed in lower latitudes also occurs near the poles. Buchan, noting the fact that the range at St. Petersburg and Bosukop is but about 0·012 of an inch, remarks: "And in still higher latitudes, at that period of the year when there is no alteration of day and night, the diurnal variation probably does not occur."

The first year's observations at Fort Conger satisfied me that such diurnal variation does occur in very high latitudes, and my opinion was confirmed by subsequent observations. Reductions made several months before the station was abandoned, from nearly five hundred days' continuous observation, showed a range of 0·0099 of an inch. The primary maximum occurs at 5 A. M., Washington mean time (which is 53 minutes slower than local time), followed by the primary minimum at 1 P. M. The secondary maximum and minimum took place at 6 P. M. and midnight respectively. To determine whether the presence or absence of the sun affected the fluctuation, I calculated separately the means of the days of continual darkness and continuous sunlight up to May 1, 1883. The diurnal fluctuation was substantially the same, and the critical hours were identical in the Arctic night and in the polar day.

The absolute range of the barometer observed was 2·032 inches—from 31, April 9, 1882, to 28·968, Feb. 19, 1883. It is interesting to note that the minimum pressure for the year 1882–83 at Godthaab and in Spitzbergen occurred respectively one day earlier and three days later than at Fort Conger. The barometer at Godthaab touched the unusually low point of 27·89.

The annual mean temperature (—3·9°) is the lowest on the globe, being 1·4° below that deduced for Van Rensselaer harbor from Kane's observations. It quite disposes of the theories of a warmer climate as the pole is approached. The maximum mean at Fort Conger agrees with that of other Arctic stations in general, occurring in July; and the monthly mean gradually declines to the minimum in February. This month, I think, is generally the coldest at Arctic stations; and, when the lowest mean has been noted in January (or occasionally in March), I believe a series of years would change it to February. The lowest monthly mean (—46·5°), for February, 1882, must give way, however, to that at Werchojansk (on the Lena), from which the following means are reported: December, —50·3°; January, —56°; and February, —53°. The highest monthly mean was that of July, 1883, 37·2°. The absolute range of temperature was 115·1°— from —62·1°, Feb. 3, 1882, to +53°, June 30, 1882.

The amount of rain and melted snow was 3·95 inches the first, and 3·82 the second year, irregularly distributed throughout the year. This small amount of precipitation may explain the non-glaciation of the adjacent country. I believe the precipitation in the interior to be less than at Fort Conger.

The wind resultants are as follows: first year, S. 61·4° E., 7,594 miles; second year, S. 67·3° E., 6,437 miles. The wind was more southerly from 2 to 4 P. M., inclusive, than at other hours during the first year, and from 11 A. M. to 2 P. M. the second year.

The mean tidal establishment was determined by me at Fort Conger from two years' observations on a fixed gauge, as follows:

High water (1,314 tides)..... 11 h. 33·9 m.
Low water (1,314 tides)..... 17 h. 45·7 m.

Complete series of high and low waters for two years, with regular hourly readings of the tide for one year at Fort Conger, have been placed in the hands of Mr. Schott. These observations, with supplementary simultaneous readings at Capes Summer, Beechy, Craycroft, Leebi, and at Repulse harbor, added to Bessel's and Nares' observations, will, I trust, enable tidal experts to determine the co-tidal curves for Lincoln Sea, and Robeson and Kennedy channels.

The temperature of the surface sea-water was carefully observed from October, 1882, to June, 1883. The temperature fell steadily from a mean of 29·2° in October to 29° in December, and then rose steadily to 29·4° in June. The ebbing tide (to the north) was from 0·1° to 0·2° colder than the flowing tide, and its mean for December was 28·9°.

The sounding of 133 fathoms and no bottom, midway between Capes May and Britannia, is significant of a different ocean along the north coast of Greenland from the shallow sea north of Asia, North America, and Grinnell Land.

Forty-eight swings with accompanying time observations were made with a pendulum furnished by the U. S. coast and geodetic survey. The observations are now in the hands of Assistant Charles S. Peirce for reduction and comparison. I regret that continued mental and physical weakness have prevented more careful and systematic treatment of these subjects. This summary is now presented, as the immediate future promises no better results from my hands.

A. W. GREELY, *U. S. Army.*

THE FLORA OF BANK NOTES.

A FEW months ago* we spoke of the algæ and bacteria that are found in the spaces between the figures and letters of coins, and that are due to prolonged circulation. Mr. Reinsch, who was the one that began this sort of investigation, has since then discovered two new species of algæ upon money—*Chroococcus monetarum*, Reinsch, and *Pleurococcus monetarum*, Reinsch.

On another hand, Mr. Jules Schaarschmidt, private teacher of cryptogamic botany at the Hungarian University of Kolasvar, has undertaken the same study on bank bills.

Upon carefully examining the edges, folds, etc., of any bank notes whatever, there may be readily seen thereon a deposit of dust and dirt. By slightly scratching the surface of the note in these places with a needle or scalpel, and afterward transferring the material thus obtained to a glass slide and mixing it with a drop of distilled water, and then examining it with a high power of the microscope (Beck's one-tenth inch objective), we may readily detect a number of schizomycetes, algæ, etc.

Mr. Schaarschmidt more particularly examined the bills of the Austro-Hungarian Bank, old (1848–49) as well as new, and Russian one-ruble bank notes (Fig. 1).

Upon all these bills, even the newest and apparently cleanest, there was found an abundant cryptogamic vegetation, as well as several microbes. The bacterium of putrefaction (*Bacterium termo*, Dujardin) was found on all the bills examined, and on all parts of their surface. In the incrustations that are found upon the edges and folds may be seen grains of starch (Fig. 2, *d*), especially those of wheat, fibers of cotton and linen (*f*, *j*), and fragments of hair, etc. Upon the Austro-Hungarian one-florin bills we find, in addition, many saccharomycetes, especially *Saccharomyces cerevisiæ* (yeast of beer). Different species of algæ of the genus *Micrococcus*, and of *Leptothrix* (to which belongs the species *e*, which is parasitic upon the tongue and teeth of man), and some *Bacilli* are other organisms that are to be found habitually in such deposits.

FIG. 1.

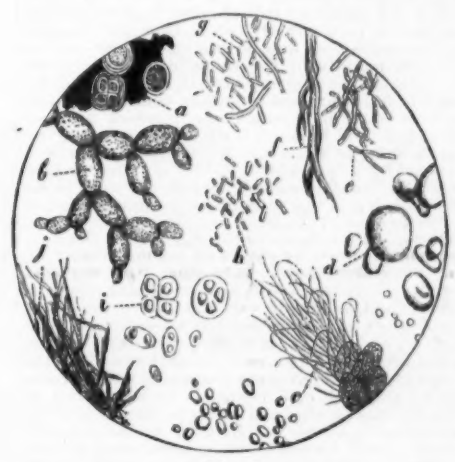


FIG. 2.

THE FLORA OF BANK NOTES.

The two new species of algæ described by M. Reinsch are very rare on bank notes. It seems that they prefer 20-franc pieces to one-florin notes, and yet these latter occasionally harbor colonies of green celled *Pleurococci*. The same is the case with the five-florin notes, which sometimes carry small *Chroococci* of a beautiful bluish green upon the surface.

In short, the following is a complete list of the cryptogams and other organisms found by Mr. Schaarschmidt upon the bank notes mentioned:

1. *Micrococcus* (Fig. 2, *a*), several varieties.
2. *Bacterium termo* (*h*).
3. *Bacillus* (*g*), various forms.
4. *Leptothrix* (*c*), various forms.
5. *Saccharomyces cerevisiæ* (*b*).
6. *Chroococcus monetarum* (*i*).
7. *Pleurococcus monetarum* (*k*).

It is evident that, from a hygienic standpoint, a microscopic study of objects that are in daily use presents great interest.—*Science et Nature.*

HOW TO GROW QUINCES.

THE quince, to be successfully grown, wants a good soil and location. Instead of being stuck into some fence corner and left to the ravages of insects, put it in a good soil that will mature a paying crop of corn or potatoes. It will do well in a dry soil if well worked. It succeeds in a moist soil, but dreads wet feet.

In planting the trees, be sure to dig a wide hole, and at least two shovel blades deep. Fill in the top soil with rich earth, like the bottom of a poultry yard or the wash of the roads, and cover all with a widespread mulch. Nothing pays better than great care in the planting.

In the third place, discard the old theory that the quince should have little pruning more than to cut out dead wood and water sprouts, with a little thinning to open the head of the tree. I prune vigorously every year from the first, cutting back from one-half to two-thirds of the length of the shoots of the new wood, and thinning so as to keep the head of the tree very open. The result is vigorous shoots, and little of the fine brush that dies along the branches of nearly all the quince trees I have seen. Meech's Prolific treated in this way sends out a fruit stem from about every bud left; and other varieties show great improvement. By this means alone, I have restored fruitfulness to barren trees.

Lastly, be sure to feed the trees well every year. A good time is in the fall and winter, when rains are sure to carry fertility to the roots, and in the spring add a sowing of salt to season their food. Any fertilizer is good. I get it from the stable, the privy, the poultry yard, the street gutter, the compost heap, and all vegetable and animal remains, which include ashes and the house slops of the chamber and wash room.

In cultivating the quince, do not use the plow. The cultivator often goes deep enough to injure the roots. The best feeding roots of the quince are near the surface of the ground. Clean culture will be found as beneficial in quince culture as with hoed crops of good husbandry. By keeping down all weeds and grass, there is no harbor for the borer at the collar of the tree. In two years, with acres of quince trees to care for, I have seen but one borer, while my neighbors have theirs bored to death.

W. W. MEECH.

CULTIVATION OF MUSTARD IN ENGLAND.

PROBABLY but few are aware of the extent to which mustard is cultivated in this country for economic purposes. The great mustard-growing districts of England are Cambridgeshire, Lincolnshire, Yorkshire, Essex, and Kent, on account of the adaptability of the soil. It is computed that the average growth of mustard in Lincolnshire is from 5,000 to 6,000 acres annually. Some persons grow from 50 to 150 acres each of the white and brown mustard; many grow less. Taking the average of the acreage of mustard in the counties named above, the quantities of white and brown are pretty nearly equal. The black-brown or red mustard, as it is variously termed, is Sinapis nigra, and grows wild in many parts of the country in cornfields and waysides. The white mustard, of which large quantities are grown in gardens for salad purposes, is S. alba, a native of the South of Europe, but now naturalized in this country. There are decided specific differences between the two. The Charlock or wild mustard (S. arvensis) is well known as a great plague in cornfields, with its numerous large and brilliant yellow flowers. The seed of Charlock is a limited article of commerce in this country; when it is reaped with wheat, the seeds are separated in the process of preparation.

The best soil to grow good crops of mustard is a deep rich one, resting on a clay subsoil; a soil impregnated with saline substances appears to produce good crops. A new soil formed out of reclaimed marshland suits the brown mustard well, and brings a bolder, fatter meal than does the old soil. The richest feeding bullock land, that is, land that will fatten bullocks without resorting to artificial food, will grow more seed, a crop freer from weeds, and of better quality than land frequently cultivated. A crop of mustard may be grown on such land three and four years in succession, and it generally proves very remunerative, returning from £20 to £30 per acre. An average crop of mustard in a favorable season is from 12 to 20 bushels per acre. Mr. A. Johnson, of Messrs. W. W. Johnson & Sons, seed merchants, Boston, who deal largely in mustard, informs me he has known such a very exceptional crop as 40 bushels to an acre. The produce of white mustard per acre is said to be a little larger than that of the brown; 20 bushels per acre is said to be a very good average crop.

Brown mustard seed is generally sown in March and April, according to the weather and the nature of the season; some sow later—in May, and even in June. The balance of advantage is in favor of early sowing. Two dangers beset the mustard plant, viz., late spring frost and the fly in early summer. The latter is called the mustard-fly beetle. It is akin to the turnip-fly, but larger and most destructive to the mustard plant. There is more danger of attack from fly through the seed being sown late, than from frost in being sown early; but the plant is tender enough to be completely destroyed from sharp late spring frosts. The seed of the white mustard is sown late because the plant is of a more succulent nature, and therefore more keenly susceptible of frost, but it will mature the crop quicker than the brown.

In sowing the brown mustard, about 4 to 6 lb. of seed per acre is used, about 4 lb. is the average sowing; if the ground is not in good condition, a larger quantity of seed is used. It is drilled in by means of an ordinary

* SCIENTIFIC AMERICAN, October 18, 1884, p. 247.

turnip seed drill, and the distance the drills are apart is regulated by the strength and richness of the land, the better the condition of the soil the wider apart are the drills. The distance varies from 14 to 20 inches. Many growers of mustard prefer to cross-hoe the crop; some will even go to the expense of singling out the plants, as is done in the case of turnips, doing this when they are from 2 to 3 inches in height. The advantage of thinning is considerable in the event of a wet season, the plants being subject to attacks of mildew, and especially when growing on good land. The mildew appears to affect the stalks of the plants especially; hence the advantage of thinning. In sowing white mustard, more seed per acre is required than in the case of the brown, because it is larger. The drills are also nearer, averaging from 6 to 10 inches or 12 inches, according to the quality of the ground.

As the mustard plant approaches maturity, and after escaping the ravages of the mustard-fly, it is subject to the attacks of a larger fly or beetle, commonly called the mustard-beetle, which will sometimes appear in such quantities as to completely destroy the crop. They attack the leaves and flower both. Their larvæ appear to infest the soil to such an extent that in some districts it is found impossible to grow mustard at all, hence hundreds of acres which a few years ago produced good crops of mustard are totally unfitted for the purpose.

The mustard crop is gathered about the end of July, when the seed-pod—which in the case of the brown is smaller and not so fleshy as in the case of the white—turns to a light brown color. It is a good plan to allow the plants to stand until the seeds get tolerably matured, as they become bolder in character in consequence, and the haulm can be placed in the stack much more quickly than when cut with too much sap in it. The crop is cut with an ordinary reaping-hook or sickle, and bundles of it are made and tied with its own straw in a peculiar manner, at which the workmen are great adepts, and the haulm sooner dries when tied in this way, should it become wet through rain. The bundles are put into sheaves, the stalks upward, and the seeds near the ground; if stood upright, as in the case of wheat, the wind would affect and burst the pods, thrashing out and scattering a good portion of the seed. In fine dry weather the crop is soon ready for carting and stacking; it is of great importance that the bundles be perfectly dry before they are stacked; the least moisture from dew or rain causes the seed to coat or turn mouldy in the stack, consequently the market value of the crop is reduced. If the crop be dry, and the stalks in good condition, containing a fair quantity of sap, and judiciously stacked, a small amount of heat will be given forth, which assists in improving the color of the seed. A mustard stack should never exceed 3 yards in width; it does not matter how long it is. By building a stack narrow, the wind blows right through it and regulates any superfluous heat, so that no harm comes from it.

The seed usually remains in the stack until October, then it is thrashed out by means of a wheat thrashing machine. One precaution is necessary: so to regulate the "riddles," by means of perforated zinc, when it comes from the machine, to suit the size of the seeds. The seed is then put twice through an ordinary dressing machine, and then it is ready for market. When brown mustard seed is in good condition and of the best quality, it should average something like 16 stones of 14 lb. to the sack of 4 bushels, net; white seed in good condition gives about 15 stones to the sack. The brown mustard is almost wholly used for manufacturing purposes, only a small quantity being sown for garden purposes. A mixture of brown and white makes the best mustard; the brown imparts pungency, the white color, to the flour.

The "Healtheries" exhibition of last year afforded opportunity to many persons to become acquainted with the manufacture of mustard for culinary purposes. The seed is put into stampers and stamped, the object being to break the shell of the seed as little as possible; then it is put through the finest wire and silk sieves. The husks of the seeds are compressed, and oil having the appearance of olive oil is extracted from them, known as oil of mustard. It is rather heavier than water, of an exceedingly pungent odor, and has sulphur among its essential constituents. After the oil is extracted the refuse is made into a kind of cake, similar to linseed cake, and which makes a capital fertilizer for potato and turnip crops.

The mustard industry is a very extensive one, and the annual produce of seed is something enormous. That it is a remunerative crop is undoubted, and perhaps has something to do in keeping some farmers in a state of solvency at a time when agricultural depression is being severely felt.—*R. D., The Gardeners' Chronicle.*

ENGLISH OAK PHYLLOXERA.

(P. PUNCTATA.)

THIS insect, which not uncommonly infests the leaves of oak trees in the south of England, is very nearly related to that well-known and much-dreaded scourge in vineyards on the Continent, the Phylloxera vastatrix, but fortunately our oaks do not suffer at its hands, or rather mouths, to anything like the extent that vines do when attacked by their Phylloxera; this is chiefly owing to the species under consideration attacking the leaves only, and not the roots as well; whereas the vine Phylloxera attacks both, but more particularly the roots. One would like to be able to speak of this insect as the Phylloxera of the oak, but unfortunately, in one's way, there is a species found on the Continent, but not in this country, called P. quercus, so that by rights that species is the oak Phylloxera. Mr. Buckton, in his "Monograph of British Aphides," remarks: "It may be well said that of all pestiferous aphidian genera, Phylloxera is the most destructive; fortunately in this country we have felt no great injury from the only known indigenous species." That our oaks might suffer very considerably from the attacks of this insect were they to become very abundant is, I think, very certain. I noticed a well-grown oak last September whose leaves were changing color and falling at least a fortnight or three weeks before its neighbors, which had, I have no doubt (though there were no insects on the leaves, owing to their dryness), from the peculiar appearance of the leaves, been attacked by this insect. This tree must have had its vitality considerably impaired to lose its leaves so much sooner than its neighbors. And though other causes might have helped to operate to this end, yet the remarkable way in which the leaves were changing color, in spots which gradually spread over the leaf in the spaces between the veins till they joined, led me to regard the Phylloxera as the cause. It seems impossible to suggest any means for eradicating this insect. No insecticide can be used with much effect on an ordinary oak tree, although in the cases of single trees or small clumps something might be done with a garden engine or Hop washing machine, and using a wash composed of 5 gallons water, 1 lb. of soft soap, and some tobacco water, or 2 ounces of soft soap and 2 ounces of flowers of sulphur boiled in one gallon of water. These insects, I believe, usually only infest the lower parts of a tree or low bushes. Where practicable the infested leaves should be picked off, and this would be well worth while doing if only a few leaves were attacked, in order to prevent the pest spreading. This insect has fortunately several insect enemies; the grubs of certain small flies devour the insects and the eggs. Fig. 4 shows a very voracious grub of some small fly, which, though only just hatched (in fact, it was not entirely free from the egg-shell), had captured and was devouring a full grown Phylloxera. I was examing a leaf attacked by this insect when I came upon this astonishing example of juvenile precocity, and at once took the young monster's portait, and it probably suffers, as most of the aphides do, from the attacks of parasitic ichneumons.

This Phylloxera attacks the under sides of the leaves, and lives on their juices in the same manner as all the aphides do, by piercing the skin and sucking out the fluids through a longish proboscis. The first time I met with these insects was on a low-growing scrubby

1, part of oak leaf attacked by P. punctata; 2, foundress surrounded by her eggs (mag.); 3, eggs (much magnified); 4, grub of small fly just hatched attacking a phylloxera (magnified); 5, winged female (magnified); 6, pupa (magnified); 7, foundress (magnified).

oak tree, and I noticed a peculiar spotted discoloration of the upper sides of the leaves. On turning them over I was surprised to find the undersides covered with small spots consisting of a number of minute dots, which on closer examination resolved themselves into the insect surrounded by its eggs. The females deposit their eggs in a very remarkable manner (Fig. 2). Having taken up their position, they proceed to lay their eggs in a circular ring round them; within this ring they form another, and again frequently a third, when they are left occupying nearly the whole of the middle of the inmost ring. Their eggs (Fig. 3) are oval and greenish in color; soon after they are laid they appear somewhat wrinkled; this is caused by the rapid development of the insect within. The young larvæ when first hatched very much resemble the young of other aphides, but they soon assume a distinctive character, and the rudiments of wings may be seen. After moulting four times the insect becomes a pupa (Fig. 6), and eventually the winged insects (Fig. 5) are produced. In this generation there are no males. The females lay eggs, and again the transformations are gone through, and other very similar winged females only are produced. From the eggs laid by these are developed wingless individuals, which deposit a few large eggs, from which the perfect insects of both sexes issue without undergoing any transformations. The females each lay one large egg, from which is hatched the female first alluded to, who surrounds herself with eggs, and so this very extraordinary series of generations is completed. The males and females are wingless, and have no mouths. The foundress, or queen mother, who surrounds herself with eggs, is scarcely one-sixteenth of an inch in length, and is of a flask-like form, with short legs and antennæ, the latter consisting of only three joints; her color is a pale transparent yellow, irregularly and sparingly spotted with red; the body terminates in a retractile ovipositor, with which the insect can easily place her eggs in any position she may desire. The eggs (Fig. 3) are very minute, oval, and of a pale greenish-yellow color. The pupæ (Fig. 6) are about one-sixteenth of an inch in length, and are of a brownish-yellow color. The winged female (Fig. 5) is of about the same length as the pupa, and measures rather more than one-eighth of an inch across the expanded wings. The head and thorax are brown, the latter being very large in proportion to the insect. The body is greenish. The upper wings are large, white, and rounded at their tips; the lower pair are small and narrow.

It may be as well here, perhaps, to allude to the Phylloxera of the vine—P. vastatrix—as it is now doing considerable mischief in some vineries in this country. Vines are so little grown in the open air in England, that the insect has not much chance of spreading if due care be taken not to introduce vines from an infected locality into a vinery, and there ought to be little difficulty in "stamping out" this pest. Any vine leaves which are covered with small galls about one-eighth of an inch in diameter should be picked off and burnt. If the roots are attacked, I should recommend the destruction of the vine and the careful clearing out of any earth which may possibly contain any of the Phylloxera. In the autumn eggs are laid by true females after pairing with the males. From these eggs in May or June only females are hatched, who are known as foundresses or queen mothers. These are frequently winged in warm countries, and they attack the leaves and puncture them in such a manner that they grow round them, forming a kind of gall about one-eighth of an inch in diameter; sometimes a leaf may be covered with two or more of these galls, within which the females lay their eggs and then die. The young are hatched in July, and at once descend to the ground and begin feeding on the roots. After four or five generations of this subterranean form, some are developed into pupæ, come to the surface, and become winged insects. In colder countries, such as the greater part of the Continent, the foundresses are not winged, but they go direct to the roots and lay their eggs there after passing through the same number of generations as those descended from a gall-making foundress. They, like them, are developed into winged aphides, which fly away to other vines and deposit their eggs, from which are produced the true males and females; these are wingless and without any means of obtaining nourishment. The females each deposit a single egg in some crack or crevice of the bark; from these are produced foundresses. The Phylloxera of the vine is very much like P. punctata in general appearance, but differs in many particulars.—*G. S. S., in The Garden.*

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